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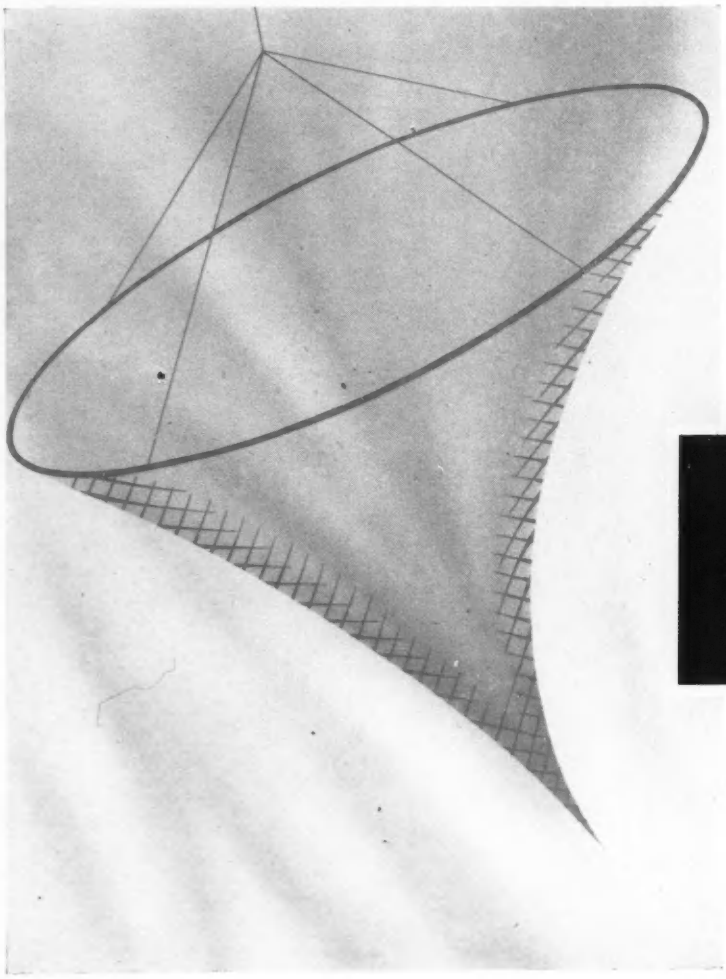

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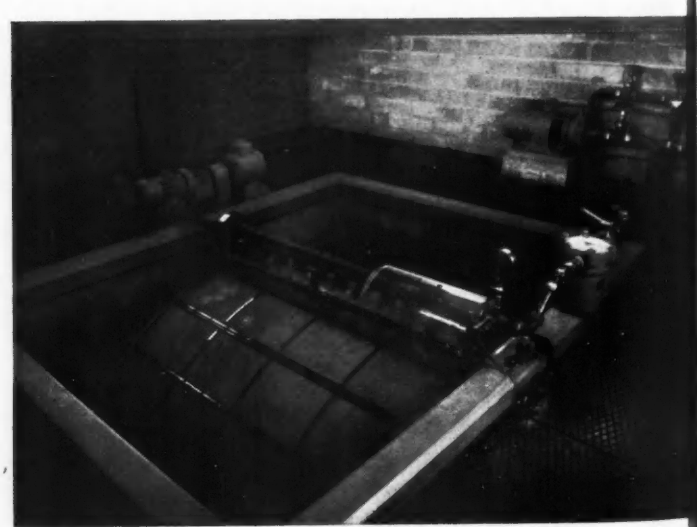

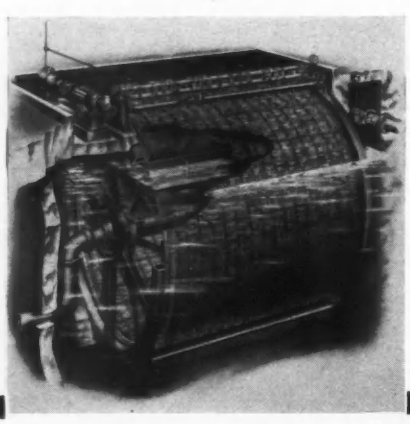

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THE ENGINEER

VOL. 201 No. 5240 JUNE 29, 1956

CONTENTS

LEADING ARTICLES—
Machine Tool Exhibition 743
High-Voltage Power Transmission ... 743
Technological Education 744

ARTICLES—
Antibiotic Production Plant. (Illus.) ... 779
British Transport Commission's Report 745
Centenary of Gilbert Gilkes and Gordon, Ltd. 756
Colleges of Advanced Technology ... 748
Colonial Civil Engineering 745
Engravings of 1871... 758
Fifth World Power Conference. No. II. (Illus.) 749
High-Voltage Power Systems: C.I.G.R.E. Meeting in Paris. No. III 775
House Construction on Expansive Soils 781
I.E.E. Conversazione 745
International Machine Tool Exhibition. No. II. (Illus.) 759
Royal Military College of Science... ... 745
Royal Show at Newcastle upon Tyne. No. I. (Illus.) 752
Steel Works Locomotives—Diesel or Steam ? 746
World Power Conference in Vienna ... 745
100 Years Ago 745

METALLURGICAL TOPICS—
High-Strength Steels. (Illus.) 754
Growth of an Austenitic Cast Iron ... 754
Effect of Stress on Thermal Expansion. (Illus.) 755
Iron-Aluminium Alloys. (Illus.)... ... 755
Zinc Alloy Die Materials 755

CONTINENTAL SECTION—
T.I.A. Feed Water Treatment. (Illus.)... 783
Tiltable Continuous Rolling Mill. (Illus.) 784
"Railway Wagons of the Future" 784

AMERICAN SECTION—
Measurement and Analysis of Industrial Noise. (Illus.) 785
Adjustable Rail Milling Machine. (Illus.) 787

LITERATURE 757

NEWS AND NOTES—
Books of Reference 753
British Patent Specifications. (Illus.)... 789
British Standards Institution 790
Catalogues 790
Forthcoming Engagements 790
Industrial and Labour Notes 782
Launches and Trial Trips 790
Personal and Business 788
Technical Reports 756

THE MACHINE TOOL EXHIBITION

Now that the International Machine Tool Exhibition at Olympia has opened its doors, it has become possible for every visitor to judge better than he could before how much ground there is for the criticisms that have been freely expressed for many months past about the failure of this country's machine tool industry to develop tools able to compete with those designed abroad, or to show much interest in electronics and automation. We doubt whether criticism will be wholly silenced, for critics are resilient people ! But certainly it can now hardly remain as vociferous as it was before the show opened. Indeed, the exhibition shows unmistakably that greater developments have been taking place in machine tool design in the last four years than have occurred, probably, in any previous so short a space of time. Each time this exhibition is held, once every four years, the visitor discovers that working precision has improved, metal removing capacity has been increased and the setting time been reduced. It was to be expected therefore that the present exhibition would show similar progress. But in addition, as every discerning visitor will quickly appreciate, this year's show indicates very clearly that the introduction of electrical and, more particularly, electronic control equipment is foreshadowing something like a revolution in high production and high precision machining methods. A very large number of machines, both British and foreign, incorporate improved means of control and operation, higher and wider speed ranges and feed ranges, greater capacity for precision work, and improved appearance. Electric and electronic control gear has been very widely adopted and many otherwise familiar machines have been made to look unfamiliar through the replacement of handwheels and levers by push buttons and switches. We do not mean to imply thereby that the basic " bread-and-butter " machine tools are being or are soon likely to be superseded, for they will long be required by industry, not least by the machine tool industry itself. But their productive capacities have been greatly increased by simplification, by the use of new means of setting up and by the introduction of various forms of preselection, copying, programming and automatic cycling equipment. These developments, in the context of industry in general, are of greater importance than others, such as the development of transfer machines which are primarily demanded by mass production concerns alone. But there are to be seen at Olympia examples of standard transfer machines, and certain special purpose machines demonstrate the application of unit heads to mass production. There is scope for criticism, but only minor criticism. For example, the latest machines are very ingeniously designed to speed the work in all ways, except apparently one. When the cutting tool itself has to be changed it still seems to remain a business, often involving clambering about the table, of untightening and tightening bolts with a spanner. Can nothing quicker be thought of ? Again, increasingly, switches and buttons are replacing wheels and levers for control purposes. But there are so many buttons that if an operator is to keep his eye on the work he has to develop a skill something like that of a typist if he is to press the right button each time. Could not the buttons be so differentiated that the operator could find the right one by touch ? But these are very small points. The big point is that the exhibition shows British machine tool makers to be not a whit behind overseas competitors in the design of almost every kind of precision and production machine tool, and fully alive to the possibilities of electronic control.

HIGH-VOLTAGE POWER TRANSMISSION

Two international conferences on power have been held this month. The fifth World Power Conference in Vienna covered the wider field, being concerned with every aspect of the production and control of energy. The sixteenth meeting of C.I.G.R.E., the international conference on large high-voltage power systems, which was held in Paris earlier in the month was more specialised, dealing as it did more with the electrical side of power generation, transmission and control. As a meeting ground for technical discussions, both formal and informal between engineers, C.I.G.R.E. is in many ways unique. It deals with a young industry which is developing very rapidly and which has to try to mature as it grows—to establish certain standards of practice without allowing those standards to hamper progress. With its study groups on special subjects meeting frequently

and its plenary assembly meeting every two years, it enables engineers who are working in similar conditions on similar problems to discuss their difficulties and thereby decide on the best solution without too much duplication or diffusion of effort. It also enables engineers whose problems are different, because the conditions are different, to compare the various methods of approach used in other countries. The resulting cross-fertilisation of ideas cannot but be beneficial both to under-developed countries struggling to develop their resources and to the more advanced countries, particularly those interested in export markets.

These ideas can be seen at work in the development of transmission schemes at very high voltages in various countries. Japan, which is going ahead with a main a.c. transmission system at 275kV, is specially interested in the possibilities of high-voltage d.c., which seems to be a promising method (in some cases, perhaps, the only method) of transmitting supplies between one island and another. No other industrial country poses quite the same problem. In Sweden, for example, although high-voltage d.c. has by no means been abandoned, there are no further obvious schemes like the pioneer system linking the mainland with the island of Gotland. The growth of very-high voltage transmission has been spectacular in Europe in the last few years. Five countries will soon be transmitting power at voltages between 380kV and 420kV. The first of these systems was commissioned in Sweden in 1952. The second, between Kuibyshev and Moscow, is coming into operation this year. Others are due to be in service in Germany and in France in 1957 and in Finland in 1958. There is no mere coincidence in the choice of 380–420kV in these cases : the conditions are generally similar, the later schemes had the benefit of Swedish experience, and there was, perhaps, the added attraction of the possibility of interconnection as part of a European network. None of these considerations was valid in the case of the 330kV system of the American Gas and Electric Company and the Ohio Valley Electric Corporation. There the choice of 330kV, based on post-war studies of load requirements, was taken independently, and on the merits of the case construction was started in 1951, and the scheme grew up at about the same time as the Swedish scheme. Apparently the operators are fully satisfied with the results and propose to use 330kV for future extensions. This voltage will therefore remain outside the 380kV standard and it seems likely to be followed in Australia and in Africa. If so, a " non-standard " 330kV would certainly create a difficulty for prospective exports by continental manufacturers.

For further developments in power transmission in the immediate future one may look to Sweden, where the very rapid growth of load in the south has exceeded the estimates upon which the 380kV transmission system was based. When the 400kV system was planned a transmission capacity of 3000MW was envisaged, whereas a total load of 8000MW is estimated for the early 1960's. At the same time, revised estimates show that exploitation of the potential water power resources in the north could be doubled. To be in a position to provide the anticipated transmission capacity Sweden is now studying the technical and economic aspects of transmission at 400kV, 500kV and 650kV. Preliminary results of these studies indicate that the " law of diminishing returns " affects the issue, that the percentage saving is of a lower order of magnitude than that achieved by the change from 220kV to 400kV in 1952. It seems to be doubtful whether the saving would justify the technical " risks " to be faced in original work at 650kV. Eventually, nuclear power will no doubt alter Sweden's pattern of transmission from north to south, for atomic power stations could well be sited near the load centres in the south. In the meantime, however, all the increase in power will have to come from the north and Sweden may well prove to be the first country to find that 400kV transmission is inadequate for its needs, compelling her to continue in the role of pioneer at high voltages.

TECHNOLOGICAL EDUCATION

A debate in Parliament last week, the issue of a White Paper on technical education last February (at a time when a dispute in the printing trade made it impossible for us to discuss it), and the more recent issue of a memorandum on the recognition of courses in technical colleges leading to the diploma in technology have, between them, greatly clarified the educational situation. The picture that emerges is that of a clear and logical plan. At the top of a pyramid stand the universities. Their expansion is to be continued with the object of providing some 60 per cent more places for students of science and technology within five years. Apart entirely from the extension of Imperial College in London, which will cost £15,000,000, the Government has recently authorised the expenditure of £4,500,000 for university buildings to be started in 1957, ahead of any conclusions that may emerge from the current review of the University Grants Committee's expenditure in the next quinquennium. That rate of expenditure needs to be compared with an average rate of about £1,000,000 a year since the post-war programme of university expansion was begun. Next come the colleges of advanced technology. How many there will be is not yet known. But five existing technical colleges at Birmingham, Bradford, Cardiff, Loughborough and Salford and the Battersea, Chelsea and Northampton Polytechnics in London, have already been so designated. They will rid themselves of all but the most advanced full-time and sandwich courses leading to the new award of Dip. Tech., and will provide facilities for post-graduate and research work. The base of the pyramid will contain regional, area, and local colleges, the first-named of which will provide a variety of courses, including full-time and sandwich advanced courses and the second of which will concentrate more particularly on part-time courses up to Higher National Certificate standard. Local colleges will provide education up to Ordinary National Certificate standard. It is planned to increase the number of students taking advanced courses by 50 per cent and to double the number of students released for part-time courses. The governmental expenditure involved between 1956 and 1961 will amount to about £70,000,000, plus £15,000,000 for equipment.

So much for the plans. How will they work out ? Criticism will certainly be based very largely upon comparisons with the similar efforts that other countries are making. Figures for the U.S.S.R. and the U.S.A. suggest that in proportion to population this country will, when the plans ripen, still be producing substantially fewer technologists per head of the population though it will be favourably placed for scientists. Moreover, though a 50 per cent increase in numbers taking advanced courses sounds very good it becomes a less impressive figure when it is remembered that as compared with 640,000 eighteen-year-olds in the country now there will be 850,000 in 1965. We do not think there can be any question but that in relation to needs the planned expansion in the rate of production of technologists and of technicians, too, is not nearly high enough. The demand for such men is already far above the rate of supply and it is easy to foresee that the development of nuclear power, advances in electronics and the increasing appreciation in almost every industrial field of the value of research will boost demand still higher. Yet our feeling is that the Government has planned for as rapid an expansion as is feasible. For the problem is not solely that of expanding and improving facilities for technological education. The people of this country, more particularly parents and school-teachers, have still to be convinced in a greater proportion than at present that technology provides a first-class, interesting and rewarding career. Had the Government decided upon a much more rapid and greater expansion of facilities we feel very doubtful whether sufficient numbers of students would have come forward to fill the vacant places.

A Seven Day Journal

British Transport Commission's Report

TO-DAY, the British Transport Commission publishes its eighth annual report and statement of accounts. They deal with the year ended December 31, 1955. The operation of the Commission's undertakings throughout the year resulted in a "working surplus" of £29,500,000. But against that has to be set a sum of £55,500,000 for central charges (mainly interest) and of £4,600,000 for capital redemption and special items. Thus, the year ended with a deficit of £31,000,000. About this, the report says that the Commission's financial results were adversely affected by a series of "external or abnormal occurrences" during the year, namely, inflation, the serious delay in authorising and putting into effect the consequent increases in fares and charges, and the railway strike. The working surplus, the report adds, was seriously insufficient to meet the central charges and the substantial deficit for the year became unavoidable. The report goes on to say that, to the working surplus last year, the railways contributed only a very small sum (£200,000). It also observes that a further substantial deficit in 1956 is inevitable, a prospect once again due, in part, to the delay in adjusting charges to meet rising prices. But, the report states, the difficult economic framework in which British Railways find themselves is also a significant factor in the outlook. The chapter reviewing development work is more encouraging. It records that capital development gathered momentum in 1955, after "long years of capital attrition." Altogether, the Commission spent about £72,000,000 on new rolling stock, road vehicles, ships, and plant and equipment, and about £9,000,000 on additions and improvements to land, civil engineering works and buildings. The first year's work on the railway modernisation plan is discussed, and among the matters mentioned are that during last year 639 steam locomotives were withdrawn from British Railways, £2,500,000 was spent on diesel locomotive building, and 136 diesel shunters were brought into use.

Colonial Civil Engineering

LAST week, the Institution of Civil Engineers held a conference on civil engineering problems in the Colonies, which was attended by nearly 200 persons. This summer conference, which occurs on alternate years, is now a well-known event in the civil engineer's calendar. This year, it included, as is customary, a number of visits to places of engineering interest around London, and it was held from June 18th to 22nd, so that delegates could also attend the Institution's conversazione on June 20th. The conference was opened on June 18th by the Minister of State for Colonial Affairs, Mr. John Hare; a lecture on "Aerial Surveying in the Colonies" was subsequently delivered by Col. G. J. Humphries. Discussion of the various papers presented to the conference took place on the mornings of Tuesday, Wednesday and Thursday of last week, and on Friday the technical sessions were concluded with a lecture on "Colonial Development and Welfare in the West Indies," by Sir George Steel. At the first technical session, new water supply schemes at Lusaka and Mombasa, and the construction of a desert town at Aden, were discussed. Railway practice and developments in East and West Africa were discussed on the Wednesday, and on the following day papers on irrigation and land drainage in Malaya, and on the construction of Ijora "B" power station at Lagos were before the conference.

The Engineer
100 Years Ago
(JUNE 27, 1856)

"METALLIC LIFEBOATS AND WAGGONS"

"Some interesting trials took place on Monday morning in the outer basin of Woolwich dockyard, with Mr. Francis's patent metallic lifeboats, and one of his metallic army waggons. Colonel Tulloh, Colonel Sandham, Major Eyre and Captain Clerk were in attendance to report on the experiments, with a view of superseding the use of wooden boats, and also of introducing the metallic waggons into general army use.

"After proving in various ways the difficulty of capsizing the boats even by more than ordinary means, some twenty blows were struck in one spot with a large long-handled axe, but without producing any permanent injury. One of the smallest boats was then put on shore, and rolled and tossed about on the pavement; then lifted up many times on its end and suffered to fall with great violence on the stones. Only a few trifling indentations were produced on the sides, but these were speedily set to rights by a few blows of a hammer. It was then launched into the water, and rowed many times against the stone pier, end on, with all the power of four men and one to steer, all of which did not injure the boat or cause her to leak. The metallic waggon was likewise placed in the water, with the whole of its running gear attached, including the pole; the weight was 17 cwt 4 lb. A number of men then got in, which brought the waggon down to within a foot from the water's edge. Attempts were then made to upset it by the whole of the men bearing down, first on one side and then on the other, but without effect. The upper edge of the waggon could not be brought below the water. The next trial was with the body alone, the running gear being detached and allowed to sink in the basin: exertions were then made to upset it, but with the same result. It was then loaded with planks and two men, weighing about 34 cwt, but neither in this case could any rolling bring the upper edge under water, the whole of the experiments turning out successful."

Royal Military College of Science

ON Wednesday, June 20th, the Royal Military College of Science, Shrivenham, held its first open day, at which members of the public were able to see something of the work which is being carried on at this establishment. Since its establishment at Shrivenham in 1946, the Military College of Science (as it then was) has increased in its importance as a centre of teaching and research relating to Army equipment, and a centre of study and information concerning the application of science to warlike purposes. The College does not work in isolation but maintains close liaison with the Ministry of Supply, the Admiralty, the Air Ministry, the Universities, a number of industrial and research establishments, and with the Staff College at Camberley, and the Army Schools. The principal courses are those for engineering and science degrees of London University, the Technical Staff course, courses for officers of the General Staff, and specialist courses such as those concerning guided weapons and nuclear science and technology. The systematic construction and proving of guns goes back to the appointment in 1716 of Albert Borgard as Colonel of the Royal Artillery. Over fifty years later, in 1772, the Military Society of Woolwich was established for the scientific study of gunnery, while in 1840 the R.A. Institution was founded at Woolwich. In 1885 the Artillery College was set up, also at Woolwich; in 1889 it was renamed the Ordnance College, but reverted to its original name after World War I, eventually becoming the Military College of Science in 1927, and obtaining its present title in 1953.

World Power Conference in Vienna

IN the Seven Day Journal last week we recorded the opening of the fifth World Power Conference in Vienna, and briefly reported Sir Harold Hartley's address given on Sunday, June 17th at the Vienna Opera House. Several other speakers, representing various national committees and United Nations organisations, spoke on that occasion, and an address was delivered by Professor Schrödinger; finally, the conference was formally opened by the President of the Austrian Federal Republic, Dr. Theodor Körner. The conference included a very full programme of technical sessions, visits and social events. The official delegates from the various countries had receptions given in their honour by the Austrian Minister for Transport and Nationalised Enterprises, at the Pallavicini Palace on June 17th, and by the Mayor of Vienna, at the Rathaus, on June 18th. Special performances of opera and chamber music, and concerts of light music, were given during the conference week. The Austrian Government also held a reception for foreign participants at the Schönbrunn Palace on June 21st. The closing session was held last Saturday. Our account of the technical work of the conference continues on page 749 of this issue.

I.E.E. Conversazione

A CONVERSAZIONE was held by the Institution of Electrical Engineers at the Royal Festival Hall on Thursday, June 21st, when more than 2000 members and guests were received by the president, Sir George Nelson, Lady Nelson and members of the council. There was an interesting display of more than a hundred exhibits and demonstrations illustrative of recent progress in electrical science and engineering. The Meteorological Office, for example, gave a demonstration of the application of facsimile telegraphy to weather forecasting. Weather charts were shown (some of them emanating from stations in the Southern Hemisphere) being built up in detail on the unattended automatic receiving equipment, without the loss of time and risk of error involved in replotting from coded information. Demonstrations were given of applications of closed circuit television and of the use of electro-magnetic pumps for liquid metals. In collaboration with the Science Museum, the Post Office gave a display showing the history of transatlantic cable communication, beginning with the original Telegraph cable of 1857/8 and leading up to examples of the new telephone cable, the installation of which is now nearly completed. During the evening a concert of vocal and instrumental music was given in the concert hall and there was dancing in the foyer.

Steel Works Locomotives—Diesel or Steam?

By M. D. J. BRISBY and J. H. TURNBULL

The authors discuss the operating capabilities of diesel and steam shunting locomotives and show that despite the higher first cost of the diesel, the lower operating costs, coupled with the greater shift and yearly availabilities, make it no longer possible for the steamer to compete.

DIESEL or steam ? This is the choice which confronts works managers every time an old steam locomotive is due for replacement. The decision is not always easy, particularly if a works has a fleet of steamers, many of which are still in good condition.

Capital expenditure is much lower with steamers, as the costs* given below for steam and diesel locomotives of comparable sizes indicate.

Steam†		Diesel†	
15in cylinder	£8,000	200 h.p.	£12,000
16in cylinder	£10,000	300 h.p.	£18,000
17in cylinder	£12,500	400 h.p.	£22,000
18in cylinder	£15,000	500 h.p.	£26,000

† These figures are only intended to give an indication and are based on a " basic model." The addition of refinements such as roller bearings, manganese liners on horn cheeks, copper fireboxes, &c., will raise the price of steamers considerably, whilst a 500 to 550 h.p. B_0–B_0 diesel-electric locomotive for steel works duty has been quoted at prices from £34,000 to £49,000.

Operating costs, on the other hand, are considerably lower for diesels. Turnbull[1], in a study of locomotive operating costs at different works, shows that costs range from 20s. to 23s. per locomotive working hour for diesels and from 27s. to 36s. for steamers. These figures, however, are based on total costs for the locomotive fleet over one year and do not give the real cost of an effective locomotive working hour. To put the merits of diesel and steam locomotives on a fair basis we must get the measure of their working capabilities in the eight-hour shift and over the year.

Two factors affect the " working hour " cost : first, utilisation, or the actual number of hours in the shift that a locomotive is usefully employed on traffic duties ; and secondly, availability, or the actual number of hours in the shift or shifts in the year that it is available for work.

These two concepts are quite distinct in so far as they provide different measures of efficiency, but they are nevertheless intimately related. Essentially, utilisation depends on the day-to-day efficiency of the traffic department, the type of duties involved, the degree of planning, and the overall level of supervision, and availability depends on the amount of servicing, maintenance and repair work undertaken and the speed with which this work is carried out. The level of locomotive utilisation must, however, depend on the general standard of maintenance, since, other things being equal, well-maintained locomotives will give better service.

Locomotive Utilisation

Utilisation figures for both steam and diesel locomotives obtained at one works under identical conditions are given in Table I.

It will be seen that :—

(i) Servicing time during the shift is very much less for diesels (about 2 per cent) than for steamers (about 20 per cent).

(ii) The time spent standing for " no work " is much greater for diesels than for steamers. This is because the diesel does not fill in time with servicing.

(iii) The " no work " times for locomotives on production jobs, whether steam or diesel, are higher than on general duties. This is because locomotives on production jobs are required to be ready to work at short notice at all times, a condition which can only be met if the locomotive is not fully occupied.

The time spent servicing steam locomotives frequently amounts to about 20 per cent of the shift time. This figure, which includes time for coaling, watering, fettling, and minor running adjustments, is unnecessarily high owing to " early finish and late start " extending these operations when they are planned to coincide with shift change-overs. Except for locomotives working on steep gradients and exceptionally heavy traffic, servicing time for a steamer in reasonably good condition should not amount to more than 10 to 12 per cent of shift time.

Delays.—Delays to locomotives are found to range from 5 to 10 per cent of total shift time in a works with an efficiently organised traffic system. The greater delays for the diesel locomotives shown in Table I are due to the fact that they operate in the more congested areas of the works. In some works delays have been found to rise to 20 to 25 per cent of the shift time, due to conflicting movements, line occupation and to accidental causes, such as derailments, mechanical faults, or lack of steam.

Delays due to conflicting movements usually come from having too many locomotives working too close to each other, and can sometimes be reduced by planning shunting operations to avoid congested areas. Line occupation delays may be due to density of traffic, but more often they are due to someone leaving a wagon where it should not be.

The most frequent cause of accidental delays is derailments due to poor conditions of track, particularly at points and crossings. Badly packed sleepers, poor drainage, and off-gauge track are current sources of trouble. Locomotive breakdowns are rare where works have good maintenance schemes, but delays due to lack of steam are frequent where locomotives are not really up to the job, as is sometimes the case with slag-tip locomotives.

It is obviously impossible to ensure full utilisation, but there is scope for improvement in most works. Extensive time studies[2] of locomotive duties have shown that the time spent on actual work for both steamers and diesels is only about 50 per cent of shift time.

The main reason for low utilisation is established custom and practice for stopping and starting times, linked with preparation times for steam locomotives and carried forward into diesel practice.

The large amount of time spent standing and recorded as " no work " may have been due to the fact that there was genuinely no work for the locomotive to do at the time, but it may also have been due to bad communications. The most practical solution here is to equip locomotives with very-high-frequency radio communication. With installation costs at less than 1 per cent of the price of the locomotive, it is a worthwhile investment.

Locomotive Availability

Availability figures for steam and diesel locomotives are given in Table II. These are useful in indicating to the works management the general level of efficiency of the locomotive fleet, but they can be misleading when used for drawing quantitative deductions between individual locomotives unless complete details are known of their condition and duties.

A comparison between Tables II*a* and II*b* shows that :—

(i) Diesels work for a much greater proportion of the year than steamers (on average 84 per cent for diesels and 65·3 per cent for steamers). Despite the differences in maintenance and operating techniques, there is remarkable consistency in the working times for locomotives in the different works.

(ii) Both shed and shop maintenance for diesels occupy much less time than for steamers (on average 7·3 per cent for diesels and 11·3 per cent for steam).

(iii) Spare time for steamers is high because it is standard practice to hold one or more spare locomotives in readiness in case of breakdowns in the working fleet.

Measured over the year, availability is largely dependent upon the age of the locomotive fleet, the duties it has to perform, its state of repair, and the maintenance policy of the works.

Age of Fleet.—It is not easy to find a true relationship between age and availability, as reliable records of locomotive failures are not generally available. Locomotives which are showing signs of weakness are frequently kept in service until their next period of shed maintenance. Moreover, it is difficult at times to assess the age of a fleet. The dates of purchase of the locomotives do not always give a true picture, as some works strip their locomotives to the frame and virtually rebuild them. The best compromise for steamers is probably to take the age of the boiler. This difficulty does not yet arise with

TABLE I—*Locomotive Occupation*

Percentage shift time

	Steam		Diesel	
	Production	General duties	Production	General duties
Shift availability :				
Utilisation :				
Running :				
Loaded, light	7·3	13·5	26·7	27·7
Shunting	40·3	33·6	18·5	18·8
Weighing	1·5	3·4	0·4	7·8
	49·1	50·5	45·6	54·3
Delays	5·2	6·0	8·1	10·9
Meals	6·2	6·3	5·6	6·2
No work	23·8	12·0	38·1	26·5
	35·2	24·3	51·8	43·6
	84·3	74·8	97·4	97·9
Servicing	15·7	25·2	2·6	2·1
	15·7	25·2	2·6	2·1
	100·0	100·0	100·0	100·0

* All costs and prices relate to conditions in the first half of 1955.

diesels, as they are all fairly new in the industry.

Duties to be Performed.—The duties a locomotive has to perform determine to a large extent the maintenance it will have to undergo, and consequently its level of availability. A locomotive working on a long haul up a steep gradient will have to be kept in better repair than one used for shunting in a flat yard.

State of Repair.—There is considerable difference of opinion on what is considered to be a locomotive in "fit state of repair," depending on the standard of maintenance in the works. This standard in turn is largely dependent on the quality of service the production departments are prepared to accept and the money management are prepared to allocate to traffic.

Maintenance Policy.—Policy has a most important bearing on availability; not only does it determine the level of efficiency of the fleet in service, but it also fixes the time locomotives spend in shed and in the fitting shop, the frequency of rebuilding, and the overall rate of replacement of the fleet.

Some works believe in spending the minimum time and money on maintenance, relying on spares when locomotives break down in service; others believe in keeping their locomotives in really good condition to make sure they do not fail. Again, some works believe in having a number of spare locomotives and carrying out repairs leisurely as and when required, whilst others rely on a minimum number of locomotives, first-class maintenance facilities and very rapid repairs.

Many works to-day have a policy of planned maintenance.[3] This means that maintenance on locomotives is carried out according to a prearranged programme which sets out the type of repairs, when they are to be carried out, and how long they should take. Ideally, planned maintenance should be based on the day-to-day working requirements of the locomotives and their expected life, and the maintenance should be fixed accordingly. In practice, what usually happens is that works have a number of locomotives to service, with limited shed and shop facilities. The nature and frequency of the repairs are worked out on a compromise between the requirements of the locomotives and the capacity of the repair shops.

Table III shows the maintenance policies adopted at different works for steam and diesel locomotives.

The table shows that there is no short cut to good maintenance for steam locomotives. Works A, B and C all believe in thoroughly good maintenance and, despite their different approach, plan to devote eight to ten weeks per year to shop and shed maintenance. Maintenance for diesels, despite different approaches at the three works, is of comparable duration when considered on a yearly basis. Comparing the maintenance schedules for steam and diesel, it will be seen that the time spent on maintenance for steamers is two to three times greater than that for diesels.

Objection is sometimes raised to the effect that planned maintenance "is all right in theory, but won't work in practice." This argument is refuted by experience. At one works a comparison made between planned and actual maintenance times gave the results shown in Table IV.

The good measure of agreement between the planned programme and the actual times taken to carry out the maintenance shows that it is possible to carry out maintenance in accordance with predetermined plans.

A further advantage of planned maintenance is that it is possible to bring past experience to bear and so set standard times for the various jobs. From these standard times it is an easy step to establish standard costs.[1]

TABLE II—*Yearly Locomotive Availability*

(*a*) Steamers.

Average age and size of fleet	Works A* 25 years (20 locos.)	Works B 32 years (10 locos.)	Works C† 14 years (47 locos.)	Works D 29 years (21 locos.)	Averages for four works
Shed maintenance	5·6	13·8	10·6	15·3	11·3
Shop maintenance	14·1	8·7	8·4	14·0	11·2
Spare	16·6	8·7	15·4	7·9	12·2
Working	63·7	68·8	65·6	62·8	65·3‡
Total	100	100	100	100	100

(*b*) Diesels.

Average age and size of fleet	Works B 3 years (7 locos.)	Works D 4 years (15 locos.)	Works E 2 years (4 locos.)	Averages for three works
Shed maintenance	2·4	8·9	10·3	7·2
Shop maintenance	7·2	6·8	8·3	7·4
Spare	—	0·5	3·8	1·4
Working	90·4	83·8	77·6	84·0‡
Total	100	100	100	100

* Two locomotives on days only (working 44-hour week—unrequired, 124 hours).

†-Eight locomotives on days only (working 44-hour week—unrequired 124 hours).

‡ From Table I, steamers are occupied on average about 20 per cent of shift time in servicing, and diesels for about 2 per cent. This means that they are not available for this time. Therefore, the working availability of steamers drops from 65·3 per cent to about 52 per cent, but for diesels from 84 per cent only to about 82 per cent on average.

TABLE III—*Planned Maintenance: Steamers and Diesels*

	Works A Frequency	Works A Time taken	Works B Frequency	Works B Time taken	Works C Frequency	Works C Time taken	Works D Frequency	Works D Time taken
(*a*) Steamers								
Lubrication	Daily	—			Daily	—		
Cleaning	3 days	—	Daily	(In traffic) 1½ h	Daily	—		
Washouts	10–12 days	2 shifts	10–12 days	2 shifts	11 days	3 shifts		
Periodic repairs	4–6 weeks	2½–3 shifts	—	—	2½ yrs.	2 weeks		
Rebuilds (major)	2½–3 yrs.	3–4 months	2½–3 yrs.	3 months	5 yrs.	3 months		
Rebuilds (partial)					5 yrs.	4 weeks		
Planned maintenance (shop and shed) per locomotive	10 weeks per year (approx.)		8 weeks per year (approx.)		9 weeks per year (approx.)			
(*b*) Diesels								
Lubrication	Weekly	2½ h	Weekly	½ h			Fortnightly —300 h	1 shift
Cleaning	Daily	—	Daily	1½ h				
Minor repairs	Monthly (500–600 h)	3 shifts	Monthly	1–2 shifts			Monthly 600 h	2 shifts
Partial repairs	2500 h	1 week	(2000 h for large locos. only)	5–6 weeks			6-monthly	4 shifts
Major repairs	20,000 h	9 weeks	2–2½ yrs.	5–6 weeks			Yearly	2–2½ weeks
Planned maintenance per locomotive	6 weeks per year (approx.)		3½ weeks per year (approx.)				3½ weeks per year (approx.)	

TABLE IV—*Maintenance Times: Planned and Actual*

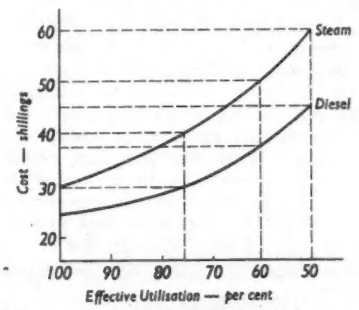
Type of maintenance	Planned programme weeks per locomotive year	Actual programme, weeks per locomotive year 1950	1951	1952	1953	1954	Average 1950–54
Major rebuilds	2·1	1·3	—	1·4	3·0	2·8	1·7
Partial rebuilds	0·8	0·7	2·0	1·2	—	0·4	0·9
Periodic rebuilds	0·8	1·1	1·0	0·5	0·6	0·5	0·7
Total time on shop maintenance (per locomotive year)	3·7	3·1	3·0	3·1	3·6	3·7	3·3

Effect of Utilisation and Availability on Costs

By increasing the utilisation of locomotives the cost per hour of effective work can be reduced considerably. If one takes steamer costs at 30s. per hour and diesel costs at 22s. 6d., then for a steamer spending 50 per cent of shift time on productive work and for a diesel at 60 per cent, the cost per hour of effective work would be 60s. and 37s. 6d. respectively; the diagram illustrates this.

Diesels do not show greater shift utilisation than steamers on the figures presented in this article. This, however, is because most traffic departments tend to use diesels at the same "pressure" as steamers, as evidenced by the figures for "no work" given in Table I. With servicing times of 2 per cent of shift time for diesels compared with 20 per cent for steamers, it should be quite possible to achieve 70 per cent utilisation for diesels. This means that fewer diesels than steamers are needed to do any given amount of work.

If one considers the shift utilisation possible with a diesel compared with a steamer, even assuming 60 per cent for steam and 70 per cent for diesel (a comparison very favourable to steam), six diesels can do the work of seven steamers. But the diesels are available for a greater proportion of the year than steamers. The diesel can work for forty-eight weeks in the year, the steamer for forty-two (Table III (*a*) and (*b*)). Thus, eight steam locomotives can be replaced by seven diesels and still provide the same availability.



Relative costs per hour of effective work for steam and diesel locomotives

Combining these two advantages produces the conclusion that only three diesels are needed to replace four steamers, which can be summarised in tabular form.

	Steam	Diesel	Comparison
(i) Utilisation ...	60% of shift	70% of shift	6 diesels = 7 steamers
(ii) Availability...	42 wks. per yr.	48 wks. per yr.	7 diesels = 8 steamers
(iii) Combined (i) and (ii)	60% for 42 wks. per yr.	70% for 48 wks. per yr.	3 diesels = 4 steamers

So far as capital charges are concerned, even on a "three for four" basis, there could still well be an appreciably greater capital involved with a diesel fleet than with steam locomotives. The present cost of a 400 h.p. diesel locomotive is £22,000 or more, whilst for a steamer of comparable power (i.e. one with 17in cylinders) the cost is about £12,500. It is interesting that in the lower power ranges the purchase price of a diesel is nearly comparable with that of a steamer. As power increases the diesel becomes relatively much more expensive. This price differential may well narrow as more experience is gained in the manufacture of large diesel locomotives, which are all of comparatively recent introduction.

Although the capital expenditure on diesels is greater than for steamers, the greater availability of the diesel means that, so far as depreciation charges are concerned, much of the difference disappears when depreciation is expressed in terms of working weeks for the fleet. Taking the above figures as an example and using the "three for four" basis, the capital expenditure for three diesels would be £66,000 and for four steamers £50,000. With 12 per cent for depreciation and interest on capital, the cost of depreciation and interest on capital would be £165 per working week for three diesels and £143 per working week for four steamers. The annual figures are £7920 and £6000, respectively.

However, with running costs, the diesels show up to great advantage. The hourly running cost for a steamer is about 30s., whilst for a diesel 22s. 6d. is an average figure. Thus, on the "three for four" basis, the steamers would be about 60 per cent more expensive than diesels on an hourly-running-cost basis.

In terms of money, three diesels would cost £27,216 for forty-eight weeks of 168 hours, plus £7920 for depreciation and interest at 12 per cent. For steamers the figures are £42,336 for forty-two weeks of 168 hours, plus £6000 for depreciation. This shows an annual saving of £13,200 for an extra £16,000 of initial outlay in the example used.

If maintenance services are assumed to cost about 7s. 6d. per hour for steam and 5s. per hour for diesel, the annual maintenance cost, on the basis of availability, works out at approximately £2100 for a steam locomotive and approximately £1800 for a diesel. This ratio has been found in practice in a works with a mixed fleet, having some post-war steam locomotives and also some diesels which have been in service long enough to have reached the stage of requiring engine and gearbox replacements.

Conclusions

Although the diesel locomotive is much more expensive than the steam locomotive in initial cost, when one combines the advantages of greater utilisation and availability which the diesel offers, one reaches the conclusion that three diesels can replace four steamers. Even on this basis the capital outlay involved with a fleet of diesels is appreciably higher than for a fleet of steamers. The diesels, however, are considerably cheaper to run, so that, after little more than a year, the savings in operating costs will cover the increased capital expense, and thereafter the lower running costs will help to reduce the cost of the work's transport services.

References

[1] J. H. Turnbull, British Iron and Steel Research Association Conference on Works Transport, 1954, pages 17–21.
[2] H. H. Mardon and M. D. J. Brisby, *Journal I.S.I.*, 1949, Vol. 163, pages 433–448.
[3] C. E. Roebuck, British Iron and Steel Research Association, Conference on Works Transport, 1954, pages 25–28.

Appendix—Maintenance Schedules

(a) Diesel Locomotives

	Frequency	Maintenance work
Works A	Daily	(By driver. Look over locomotive, check oil and water levels, lubrication
	Weekly ...	(By fitter and driver). Same as daily, plus check battery and generator; clean filters, check shaft cover and connecting-rod bolts; inspect fuel injection nozzles; blow-out motors and grease bearings
	Monthly : (500–600 hrs.)	(By engineers in locomotive repair shop). Locomotive blown out with dry air, positioned over pit, covers off traction motors, brush gear checked, oil changed, cylinder head gaskets checked
	2500 hrs. ...	(By engineers in repair shop). Includes monthly inspection. Testing air brakes, removal of cylinder heads, thorough cleaning, checking valves and seats and grinding in, draw pistons and clean, liners inspected for wear, check camshaft drive, governor and fuel pump. Hot spot plugs examined and changed if necessary. Fuel and lubrication oil circuits checked by hand pump. Examine and overhaul traction motors
Works B	Daily	Lubrication and superficial cleaning. Minor adjustments carried out in running shed if necessary
	Weekly ...	Air filter changes. Minor adjustments carried out in running shed if necessary
	Monthly ...	Oil changed, general inspection, brake blocks, adjustments to fuel sprays and minor repairs. Engine thoroughly cleaned
	2–2½ yrs. or 2000 hrs. (depending on type of locomotive)	This includes monthly inspection, wheel turning and a complete engine and transmission overhaul
Works D	Fortnightly : 300 hrs.	Clean engine filters, &c., lubricate all parts. Check all oil levels, belts, &c., check and adjust brakes, sanding; check transmission, gearbox, &c.; check frame, side rod bushes, drawbar, buffers, &c.; check contactors, generators, traction motors, compressors, batteries, &c.
	Monthly : 600 hrs.	Check all lubrication points; clean or renew filters and lubricate as necessary; remove and clean injectors, valves, &c.; tappet clearances. Remove crankcase covers, thorough internal inspection, camshaft, &c.; check and adjust all brake gear, sanding gear, axleboxes, bogies, wheels, springs, bearings, &c.; thorough check of all gearbox and transmission and all lubricants and lubrication systems Insulation tests; check generators, traction motors, compressors, batteries, lights, ancillary equipment, &c.
	Six-monthly	Repeat work tested under "monthly." Clean air compressor, air filters, oil strainers, drain and flush cooling system; remove cylinder head, decarbonise, grind in valves, grind and check air start valves. Check all brake equipment, remove and inspect air compressor valves, check crankshaft alignment. Repeat three-monthly Remove cylinder head and carry out whatever work is necessary
Works C	Daily	Lubrication by driver in traffic
	11 days ...	Washing out, tube sweeping, general cleaning and mechanical adjustments
	3 yrs.*	General mechanical overhaul
	6 yrs.*	Full mechanical overhaul, including tyre turning and lesser boiler repairs
	6 yrs.*	Full mechanical overhaul, including tyre turning and lifting boilers out

(b) Steam Locomotives

	Frequency	Maintenance work
Works A	Daily, 3 days	Lubrication and cleaning by driver. Thorough cleaning by special squad
	10–12 days ...	Cleaning, washing out, tube sweeping and adjustments
	4–6 weeks ...	Locomotive withdrawn from service for minor adjustments and repairs, reconditioning of connecting-rod brasses, slippers, cams, clacks, injector valves, and adjustment and fitting of brake blocks
	2½–3 yrs. (2–2½ yrs. for light locos.)	Locomotive thoroughly examined and parts requiring replacement or repair passed to engineers who plan rebuilds. Costs readily obtained by reference to works order
Works B	Daily	Lubrication, superficial cleaning, minor repairs, brake adjustments, new gauge glasses, &c.
	10–12 days ...	All minor running repairs and locomotive thoroughly cleaned, washing out
	2½–3 yrs. ...	Almost always includes a boiler patch, major work on wheels, boxes, &c.; locomotive repainted

* Periodic repairs are carried out on the following schedule :—

Minor overhaul	2 weeks	
Working		80 weeks
Major/minor overhaul ...	5 weeks	
Working		50 weeks
Minor overhaul	3 weeks	
Working		111 weeks
Major overhaul	11 weeks	
Working		50 weeks
	21	+291 = 6 years

Colleges of Advanced Technology

During a debate on technical education, on Thursday of last week in the House of Commons, the Minister of Education, Sir David Eccles, announced the proposals for "colleges of advanced technology." These colleges, the Minister said, would concentrate entirely on work above the level of the Ordinary National Certificate, including post-graduate and research work. They would cover a broad range of technologies, and would earn 75 per cent grant for all their advanced technological work. To qualify for designation, the Minister stated, a college must fulfil a number of conditions. The conditions were fairly stiff, and covered such matters as the composition of the governing body; the financial control of the college, for the purpose of giving the colleges a certain liberty which they should have in view of their position; the staffing arrangements, and the standard of accommodation required.

The Minister went on to say that he proposed to designate eight colleges of advanced technology, with two more in sight. The eight on the list were provisional, because, the Minister said, he still had to satisfy himself that in so far as the colleges selected did not already fulfil the necessary conditions they would be able to do so in the very near future. The colleges designated were: the Birmingham College of Technology, the Bradford Technical College, the Cardiff College of Technology and Commerce, Loughborough College of Technology, the Royal Technical College (Salford), and the Battersea, Chelsea and Northampton Polytechnics in London. There were important areas, the Minister continued, in which no college was at present suitable for designation, but he thought there were two special cases. One of them was the north and north-east, which included the growing industries on Tyneside and Tees-side. The Minister added that he felt in an area of such importance one of the regional colleges should be promoted to be a college of advanced technology. He was therefore asking the local education authorities concerned to confer together and to consult with industry through the medium of the Northern Regional Advisory Council. The Minister said also that in the south-west, no college was yet far enough ahead to be designated. He had added the Bristol College of Technology to the list of regional colleges, and had agreed with the Bristol authorities that they should plan their building proposals so that if, as was to be hoped, enough support was forthcoming from industry, the Bristol College of Technology could graduate to the status of a college of advanced technology.

Fifth World Power Conference

No. II—(*Continued from page 707, June 22nd*)

Our account of the recent conference in Vienna continues with reviews of the papers on gaseous fuels and long-distance gas pipelines. This is followed by an account of present-day trends in thermal-electric installations, including turbo-generator and boiler design, district heating, and combined steam and gas turbine cycles.

THE gasification of fuels and the preparation of gaseous fuels were discussed in section "E" of the congress. Here, as would be expected, many trends apparent in section "C" (solid fuels) were again to be found. The general report for section "E" was written by Professor Orlicek, of Vienna Technical University; a brief abstract from his report is given hereunder. It is followed by a general review of the development of long-distance gas transmission lines, a subject of special interest in which ten papers were submitted (section "F"); the general review of section "F" was by Professor Orlicek and Dipl.-Ing. J. Schwimann.

Since the conference of 1950 the use of gas, both for public supply and for industrial purposes, has increased substantially. (Papers E/4, 6, 19, 22 and 23.) This development has been made possible to a considerable extent by the use of natural gas, in particular in the United States of America (E/6). In recent years, however, important resources of natural gas have been made available also in Mexico (A/26) and in various European countries (F/6, F/8, F/2, F/4), and it is to be expected that it will be possible to utilise still more sources of natural gas. To the conventional process of gas production by the carbonisation of coal, which is still in many countries the main source of public gas supply, an increasing number of new methods have been added, as, for instance, the complete gasification of coal, particularly of low-grade coal, and the gasification of oil.

Both the demand for gas and the demand for coke have been steadily increasing. The principal user of coke is, as before, the iron industry, which, in spite of the existing tendency to diminish the heat consumption and thus also the coke required per ton of crude iron, needs more coke as a result of continually increasing production. At the same time, large quantities of coke go for domestic heating. In spite of many endeavours to introduce new processes into the iron industry, in addition to the traditional blast-furnace process, whereby the use of blast-furnace coke may be dispensed with, it must be assumed that the demand for such coke will not only continue in the coming years, but that it will further increase. The demand for coke for domestic heating is also likely to show an upward trend. The European coking industry has nevertheless to cope with difficulties and in many cases operates with an extremely narrow margin of profit, because coking coal has become very scarce and must frequently be purchased at unfavourable prices from distant collieries or be imported. Efforts are being made to increase throughput in order to reduce the specific capital expenditure as well as to increase the life of coke ovens and to reduce the number of employees. Particular importance must be attached to endeavours to replace the rich gas, which was formerly always and is even now still occasionally used for heating coke ovens, by lean gas in order to keep the rich gas available for public gas supply. Another very important factor is the utilisation of the sensible heat of the coke, whereby the coking process may be rendered considerably more economical. Report E/18 gives a very detailed survey of all these problems in Great Britain, and it may be assumed that similar problems probably exist also in all other countries.

The shortage of coals suitable for the production of high-grade blast-furnace coke has also given rise to attempts to produce coke-like products from other qualities of coal with simultaneous production of gas. Particular mention must be made of processes for the low-temperature carbonisation of coal which are reported in paper E/19 and by which, in addition to producing gas, a semi-coke is obtained.

These various developments, which in many cases are still in a semi-technical stage, make it appear quite probable that in some distant future a large part of metallurgical coke will be produced by new methods and from new raw materials. A technical development which took place in Great Britain several decades ago is of considerable interest, namely, the carbonisation of coal in continuous vertical retorts, which is dealt with in E/16. Whilst, as far as is known, vertical retorts are used on the Continent only in rare cases and then only by small gasworks, large town gas plants of this kind exist in Great Britain, and such plants have been erected even in recent times. Advantages of vertical retorts are the fact that an installation requires little space, and also the avoidance of smoke and dust production; the coke is quenched in an enclosed space by means of steam which is utilised in the retort itself for producing water gas, so that the sensible heat of the coke is not lost.

The development of new gasification processes for coal dust, fine coal and high-ash coals is, as already mentioned, of particular importance. These methods, which were also discussed in detail at the International Conference on Complete Gasification of Mined Coal, held at Liège in 1954, are reported in paper E/22. These new methods aim, not only at producing a gas having the approximate quality of synthesis gas or of town gas, but also at obtaining lean gas, which is frequently in urgent demand, because it is used for the heating of coke ovens, whereby it is possible to make rich gas available for other purposes.

Attempts have long since been made to combine the generation of power with the process of low-temperature carbonisation. In such low-temperature carbonisation power plants gas and liquid products are obtained from the fuel as well as a low-temperature coke, which is subsequently burnt under the boiler. Paper E/24 gives an interesting account of Russian projects to utilise waste wood in this manner. There can be no doubt that this project is most attractive because of the relatively high percentage of volatile substances contained in wood.

The general report also deals with the basic processes involved in the gasification of oil and the chemical conversion of gaseous fuels.

Long-Distance Gas Supply

Since the fourth World Power Conference the increasing importance of gas as source of energy and as raw material has led to a rapid expansion of gas supply installations. The United States of America are at the head of this development. In 1953 the mileage of the long-distance gas supply pipelines (excluding distribution mains and field pipes) reached 125,000 miles, with a daily capacity of $23{,}300 \times 10^6$ cubic feet of natural gas. The heat of combustion of the natural gas satisfies 25 per cent of the entire energy demand of the country (compared with 29·3 per cent covered by solid fuels, 66 E/6). Although the importance of gas distribution is growing more slowly in other continents, the beginnings of such a development are becoming evident also in Europe. In Italy long-distance natural gas pipelines attained a length of 1860 miles in 1954 and their capacity totals 707×10^6 cubic feet per day. The natural gas supply system of Italy satisfies 8 per cent of the entire energy demand of the country (compared with 27 per cent covered by solid fuels). These are figures the importance of which should not be underrated, since hitherto Italy has been largely dependent on her solid fuel imports, water power of any magnitude being available only in her northern provinces. Large natural gas reserves have also been found by boring in South-West France, at the northern edge of the Pyrenees. They supply a natural gas distribution system the long-distance pipelines of which attained about 342 miles in length in 1955, with an annual gas distribution capacity of 8830×10^6 cubic feet. Since new and considerable sources of gas have been found by boring at Lacq, it is proposed to extend the long-distance transmission system as far as the industrial area of Lyon and St. Etienne (200 F/8).

In addition to these countries, which, as far as can be deduced from the papers, are in the lead in the distribution of natural gas, there are other places where long-distance gas pipelines have been installed and existing long-distance transmission systems further extended. Thus, the following natural gas pipelines have been completed: a pipeline extending 348 miles, from Sui to Karachi in West Pakistan; a pipeline extending 530 miles, from Yelshanka, on the Volga, to Moscow, U.S.S.R., and another extending 1100 miles from the Commodore Rivadavia field to Buenos Aires, Argentina. In 1951, a company in the United States of America worked out a plan for a long-distance natural gas pipeline to extend 2500 miles from the Middle East oilfields as far as Paris, Western Europe, with a daily capacity of 1×10^9 cubic feet. Even though the final stage of this scheme is far from being reached, the mere fact that such schemes are being prepared and discussed among experts demonstrates the trend of development.

Finally, it should be mentioned that natural gas has been found by boring in Austria, hardly an hour's driving time from the conference headquarters. The fact that no paper has been submitted on this subject, as well as the fact that at present natural gas resources are still not being utilised to an extent commensurate with their size—which would be desirable for the economy of this country—is due to the use of the natural gas fields and oil wells being withheld from the Austrian state until a year ago. However, it can be recorded that in the year 1955, 5648×10^6 cubic feet were used for the municipal gas supply system of Vienna, 8190×10^6 cubic feet for the generation of electric power, and 7872×10^6 cubic feet for various other purposes (mainly for industrial heating). It is intended to increase the use of natural gas approximately twofold in the very near future, and it is also intended to construct a long-distance pipeline to transport the gas to the south into the Styrian industrial area. Although the above-mentioned figures are very small compared with the utilisation in other countries, the use of even these comparatively modest quantities of natural gas is very important for Austria, because this country has to cover a considerable part of its fuel demand by imports.

In countries without adequate natural gas resources, the construction of extensive gas distribution systems is generally proceeding with less vigour. The quantities of surplus gas, however, particularly of coke-oven gas, available for long-distance supply to areas with appropriate demand, are increasing in the same measure as the rationalisation of the heat economy of heavy industry, especially of steel works and coke-oven plants.

The fact that in various countries very different methods of construction are used may be due to a certain extent to the particular local conditions, but technical development has not yet come to an end. This applies not only to purely technical factors, such as the pressure to be selected, the arrangement of compressor stations in long-distance lines and other problems, but marked differences also appear, for instance, in factors of safety in the calculations of the strength of pipelines.

Opinion is unanimous that only steel pipes with welded joints should be considered. But with regard to the type of welded joint, opinions differ widely. In some countries butt welding is preferred, in others socket and spigot welding, owing to the difficulty of keeping the pipe dimensions within very narrow tolerances. Since certain designs of sockets and spigots also allow the pipeline to be adapted to the terrain in a comparatively simple manner, the application of socket and spigot welding undoubtedly offers certain advantages. The inclusion of flexible joints is generally not considered necessary, except where very substantial earth movements may occur in the terrain concerned (mining areas are, of course, an extreme example of such

conditions). Very different opinions are held about dimensioning pipelines in relation to their strength. While in some countries an extremely careful and conservative view is taken, in other countries it is believed that high factors of safety may to a large extent be dispensed with, and experience seems to justify the latter opinion. Great importance has always been placed on the testing of welded joints in long-distance pipeline construction.

The selection of means of protection for long-distance transmission systems shows a certain amount of variety. This is due to some extent to the difference between coke-oven gas and natural gas. Coke-oven gas is particularly liable to cause corrosion and dust deposits, and hence it is necessary to use special methods of construction which are capable of standing up to these conditions. Where there is danger of corrosion of the pipeline, the practice has frequently been adopted of checking the thickness of the wall by a radioactive method.

Energy Utilisation

We now come to the most heavily subscribed division of the congress, namely, Division II, on the " Utilisation of primary sources of energy." The division is considered under the four main sections of thermal (section " G ") ; hydro-electric (section " H ") ; and atomic energy (section " J ") installations and other sources of energy (section " K "). These sections are subdivided, with general reports on each sub-division, as listed last week.

The Design of Thermal Power Stations

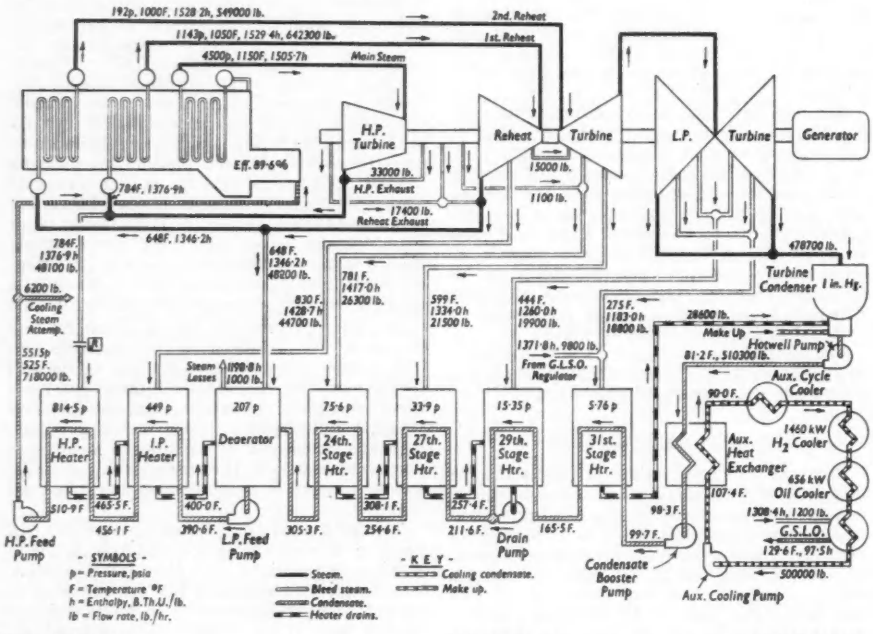
Noteworthy progress is recorded in the various aspects of electricity generation ; the background to this achievement is one of continually increasing energy consumption, and of growing shortage of fuel, in particular coal for boilers. The general report on section " G_1," on the layout and design of thermal power plants (by Professor H. Melan, Vienna University) is particularly informative, and section " G " generally is reviewed here by abstracting from it. Thus the second two sub-sections, which deal with boiler technology and mechanical design of plant respectively, are not reported in detail, although some of the more general aspects of these two subsections overlap with " G_1." Nevertheless, constructional details and problems of great interest were discussed. We were interested to note the strong Russian contribution (twelve papers) in section " G_2."

Apart from larger sizes, improved efficiencies and higher steam conditions in the design of turbo-alternators, other topics of special interest in section " G " included several papers on combined cycles for steam and gas turbines, and the use of free-piston gas generators. Combined thermal-electric generation was also given considerable attention. District heating schemes in combination with electricity generation are in use in several European countries, and are described in the section " G " papers.

We have also included some diagrams, taken from individual papers. Fig. 1 shows the heat cycles of the super-critical turbo-alternator set at the Philo station of the Ohio Power Company (paper 123 $G_1/18$). The set has a capacity of 125MW, with a boiler rated at 675 klb per hour at 4500 lb per square inch and 1150 deg. Fah, and two reheat sections, and the turbine is a 3600 r.p.m. tandem compound, double-flow machine. Figs. 2 and 3 show combined gas and steam turbine cycles. These topics are referred to in the abstract below, from Professor Melan's general report.

It is outside the scope of this general report, he writes, to render a complete survey of all problems involved in the construction of thermal power stations. No attention will be given to some new and important developments in power plant design, such as progress made in measuring techniques and television monitoring.

New large-scale power plants being built in the United States and Europe show considerable differences in design. In the United States, total installed capacity in a thermal power plant has already reached the 1,400,000kW mark. Unit capacity in the largest power stations reaches 200MW, and units of 340MW capacity are under construction. All these large installations are operating on the unit principle. In addition to attaining maximum output per unit of boiler, turbine and generator, power engineering in the United States employs all measures to improve efficiency, such as (*a*) highest pressures and temperatures, (*b*) multiple reheat cycle, (*c*) extensive bleed steam preheating of feed water, and (*d*) utilisation of highest vacuums, applying these techniques to a greater extent than is usual in Europe at present. Highest live steam conditions before the turbine stop valve so far used in the United States amount to 350 atmospheres and 650 deg. Cent. (5000 lb per square inch gauge and 1200 deg. Fah.). The generator for this steam is a monotube boiler, now under construction ($G_1/1$), designed for 362 atmospheres and 650 deg. Cent. (5140 lb per square inch gauge and 1200 deg. Fah)., at a rating of 907 t/h (2,000,000 lb per hour).



R—Resistance orifice.

Power plant data :

Gross generation	127,000kW
Auxiliary power	9,440kW
Heat input	1008×10^6 B.Th.U./hr.
Net generation	118,160kW
Net plant heat rate	8530 B.Th.U./kWh

Fig. 1—Full-load heat cycle of 125MW generating set at Philo. The set is super-critical, with steam conditions of 4500 lb per square inch and 1150 deg. Fah. and multiple reheat

In the United States, boilers up to 170 atmospheres are still predominantly of the vertical tube natural circulation types. Higher pressures require construction of forced-circulation boilers, since natural convection becomes insufficient. To ensure optimum boiler efficiency flue gas temperature is reduced to 93 deg. Cent. (200 deg. Fah.). Conditions exceeding critical pressure and the temperature of 565 deg. Cent. (1050 deg. Fah.), which is critical for ferritic steels, have largely been met in the United States by utilising austenitic steels for the construction of large power plants. (See paper $G_1/18$.)

In Europe, the largest set operating to-day is rated at 150MW. Units of 200MW are under construction. No need has prevailed in Europe so far for the construction of power plants of larger capacity, such as currently built in the United States. Reasons for this different trend are to be found in the relative decentralisation of power production, resulting partially from the location of collieries, as, for instance, in the United Kingdom ($G_1/24$), and in the average *per capita* consumption in Europe, which is still considerably lower than in the United States. In the United Kingdom, however, plans are already under way to erect power stations of 1,000,000kW capacity comprising five 200MW units.

Due to the fact that in Europe, in general, the annual load factor of the installed capacity of the large power stations belonging to public supply undertakings remains comparatively low, the incentive for full utilisation of all technical possibilities is naturally not so strong as in the United States, and therefore it is preferred not to increase live steam temperatures above 530 deg. Cent. (985 deg. Fah.), so as to permit employment of ferritic steels.

For subcritical conditions it appears that the forced-circulation boiler, in the form of the Sulzer monotube type ($G_1/2$), and steam generators of the Benson type, as developed by Messrs. Siemens in conjunction with German boilermakers, are becoming more widely used.

Even in Europe, however, individual industrial power plants with high load factors have already operated with turbine inlet temperatures above 600 deg. Cent. (1110 deg. Fah.). Since trials in these plants have shown favourable results, future design of large steam power plants for public utility purposes will certainly be influenced by them ($G_1/9$).

For the fixed number of two reheat stages, the most favourable inlet pressures for inlet temperatures above 600 deg. Cent. (1110 deg. Fah.), are in the super-critical range. In the United States ($G_1/1$), three plants operating with super-critical inlet steam conditions are now in service or under construction. The characteristic data of these plants are as follows :

Output, MW	Inlet pressure		Inlet temperature		Number of reheat stages
	Atm.	P.s.i.g.	Deg. Cent.	Deg. Fah.	
325	351	5000	648	1200	2
125	316	4500	621	1150	2
250	246	3500	594	1100	2

Relevant data for the 325MW plant show a heat rate of 2140 kcal per kilowatt-hour (8560 B.Th.U. per kilowatt-hour), corresponding to a thermal efficiency of 40 per cent.

With regard to large capacities, current development of the steam cycle process has thus reached its limits to-day. Future possibilities of additional improvement in thermal efficiency will primarily depend on the development of high-temperature-resisting steels, since a noticeable reduction in specific heat consumption can be achieved only by an increase of inlet temperature.

The desired objective, however, might also be attainable by another method. Progress may be reached by complete Carnotisation of the upper stage of the cycle, that is, by increased isothermal expansion in the turbine. Actually Carnotisation of the cycle has already occurred in the lower stage due to the extensive use of bleed steam preheating of feed water.

Turbine Units.—In the large power stations in

the United States the following turbine units are now mainly being employed ($G_1/1$) :

Single shaft turbine units	40 to 250MW ...	3600 r.p.m.
Double shaft turbine units	165 to 325MW ...	3600/1800 r.p.m.

Depending upon circumstances, steam conditions are : 102 atmospheres, 540 deg. Cent. (1450 lb per square inch gauge, 1000 deg. Fah.) on non-reheat cycles, 168 atmospheres, 565/565 deg. to 594/565 deg. Cent. (2400 lb per square inch gauge to 1050/1050 deg. to 1100/1050 deg. Fah.) on reheat cycles.

European plants are chiefly using one-shaft units to-day. At present, units of this type are under construction for capacities of 200MW, at 3000 r.p.m. To a certain degree, standardisation of turbine units appears to be coming into greater use. The United Kingdom, for instance ($G_1/24$), at present uses the following turbine units in the 3000 r.p.m. category :

	Output of unit	Live steam condition		Thermal efficiency of total installation connected by unit principle
		Pressure	Temperature	
	MW	atm.	Deg. Cent.	Per cent
Units operated on non-reheat cycles	60	63	500	31·5
	60, 100	105	550	32·0
Units operated on reheat cycles	100	105	525/515	33·0
	120	105	550/550	33·5
	200	165	575/550	35·5

Heat-Electric Plants.—Parallel development of power and heat demand in major urban districts has increasingly prompted public electricity undertakings to supply both kinds of energy and to construct heat-electric power plants. In every specific case, however, detailed investigations are necessary to ascertain the most favourable layout of a projected heat-electric station ($G_1/10$, 11, 14, 15, 16, 17, 26). These investigations particularly concern the choice of the most suitable medium of heat transmission and pipework design, as both factors decisively influence economic operation of the plant.

Progress made in the design of municipal heat-electric stations, and constructional details of projected power stations of this kind are discussed in the papers of several countries ($G_1/10$, 14, 16, 17). New plants in Czechoslovakia and Poland invariably combine supply of space heating energy with that of industrial steam, while co-operating in a power distribution system with hydroelectric and condensing power plants. Specific economic studies of the typical layout of heating power stations in Poland ($G_1/16$) have established that most favourable live steam conditions for medium-sized stations (16 to 30 t/h live steam supply) are obtained at 36 atmospheres and 435 deg. Cent. (510 lb per square inch gauge and 815 deg. Fah.).

Heat-electric stations designed to provide both industrial steam and space heating energy are installing either pass-out turbines or separate back pressure turbines to fulfil their dual task. The generators driven by these turbines are electrically synchronised.

Combination of Gas Turbine and Steam Power Plants.—The combination of gas turbine and steam power plants is aimed at increasing the thermal efficiency of the plant as a whole. The basic idea has been borrowed from the well-known mercury-steam process. This process proposed to circumvent difficulties in the improvement of the pure steam process by the increase of live steam temperatures and pressures in the absence of suitable heat-resisting constructional materials. The fact that, at equal temperatures, the pressure of mercury vapour was considerably below steam pressure suggested division of the entire process into a high-temperature mercury vapour stage and a low-temperature steam stage. In this divided process, steam was generated by the heat given up by condensation in the mercury stage.

Various possibilities of combining gas and steam turbines mentioned in the papers $G_1/11$ (France), $G_1/20$ (Italy), $G_1/13$ (Czechoslovakia), $G_1/6$ (Austria), and $G_3/4$ (United States), prove that the idea of increasing efficiency by methods of combination has already received general attention. The gas turbine is arranged before the steam unit (upper stage), and part or all the waste heat recovered from the gas turbine is utilised in the subsequent steam cycle (lower stage).

The simplest type of combined unit ($G_1/6$) works on the principle of utilising the waste gases of the open-cycle gas turbine in a waste heat boiler connected to the turbine outlet side. Gas turbine operation is without preheating or cooling of the compressor. In systems designed for single-stage intercombustion, an efficiency equal to that of the once-through gas-steam cycle can be reached at initial temperatures in a range 100 deg. Cent. (212 deg. Fah.) below the comparative point in the once-through process, which is of great importance with regard to the use of cheaper construction materials. The logical conclusions to be drawn from this fact suggest application of the principle of isothermal expansion. With a view to using solid fuel and in order to ensure better control of the gas-steam cycle, designs envisage an intervening heat carrier cycle which, as a closed system, transfers the heat of the exhaust gases to the working fluid of the gas turbine process. This indirect heating of the working fluid at the same time facilitates realisation of isothermal expansion. These proposals are based on an approximately equal distribution of output between gas turbine and steam turbine.

In the following combinations, however, the steam turbine unit is far more powerful. With efficiency in the steam stage being the decisive factor in these designs, the improvements obtainable by the combination of steam and gas turbine plant are relatively slight.

The paper $G_3/4$ proposes several combinations, including (*a*) utilisation of waste gases from a gas turbine for preheating feed water in a steam power plant. (*b*) Utilisation of waste gases from a gas turbine for preheating the combustion air of the steam generator. (*c*) A combination of gas turbine combustion chamber and boiler. The waste gases of the steam boiler operating at an excess pressure of several atmospheres, supercharge the gas turbine. The heat contained in the expanded waste gases is also harnessed for regenerative preheating of compressed combustion air (see Fig. 2).

The paper $G_1/13$ discusses the possibility of introducing reheat in a steam cycle by the installation of a reheater between the gas combustion chamber and the turbine element of a gas turbine unit. This design, abandoning the usual recycling of steam to a reheater installed in the boiler, permits application of a higher temperature in the turbine combustion chamber without the risk of exceeding the maximum temperature permissible in gas turbines. In this process, known as " dual fuel system," the steam generator, fired with cheap solid fuel, carries the major share of plant output, while the high-grade fuel fed to the gas turbine plant is exploited at high efficiency. This design, also, utilises the gas turbine waste gases for regenerative air preheating in the turbine plant. Subsequently, the gases are also harnessed partly for feed water preheating, and partly for air preheating for the boiler combustion chamber.

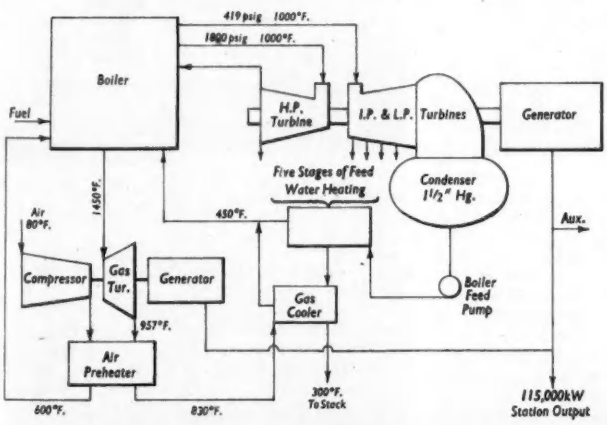
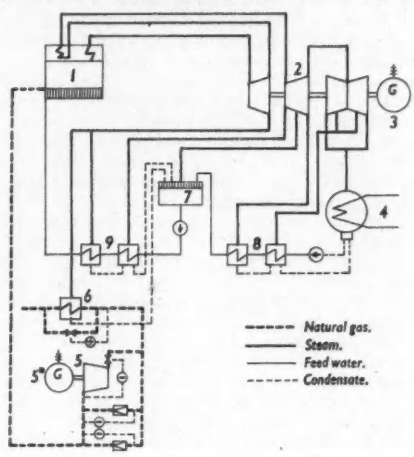


Fig. 2—Diagram of 115,000kW combined steam and gas turbine supercharged boiler plant. The gas turbine output alone is about 15,000kW, and the efficiency (L.C.V.) of the set is 41 per cent



Gas pressure at turbine inlet...	48 kg/sq. cm. abs.
Gas temperature at economical load ...	210 deg. Cent.
Gas temperature at full load...	218 deg. Cent.
Back pressure at turbine outlet	2 kg/sq. cm. abs.
Enthalpy drop really utilised	87 cal/kg
Economical output at alternator terminals	1·01MW
Maximum continuous output at alternator terminals	1·3MW
Efficiency rise of the steam installation...	2 per cent
Overall efficiency of the installation (L.C.V.)	0·37

1—Boiler.
2—Turbine.
3—Alternator.
4—Condenser.
5—Natural gas expansion turbine.
5*—Asynchronous generator.
6—Natural gas preheater.
7—Feed water tank reservoir.
8—Feed water low pressure preheaters.
9—Feed water high pressure preheaters.

Main steam turbo-set :	
Economical output	50MW
Rated output (or maximum continuous output)	62·5MW
Inlet steam temperature	510 deg. Cent.
Inlet steam pressure	126 kg/sq. cm. abs.
Superheating temperature	510 deg. Cent.
Specific consumption	2375 cal/kWh*
Gas expansion turbo-set :	
Gas flow at economical load	10,000 kg/hour
Gas flow at maximum load	13,000 kg/hour
Gas pressure at delivery point	51 kg/sq. cm. abs.

Fig. 3—Natural gas expansion turbine combined with steam power station at Tavazzano

In the case of high-pressure natural gas supply, as in the Italian power plant of Tavazzano, it is advisable first to expand the gas in an expansion turbine ($G_1/20$). The total output of the station then increases by 2 per cent. Efficiency can furthermore be raised substantially if the natural gas, prior to burning directly in a boiler furnace, is utilised to operate an open cycle gas turbine. Waste gases may be used for steam generation, or for superheating natural steam (Fig. 3).

Special attention is called to proposals concerning the combination of power and heat production ($G_1/11$, 22). The project designs for the St. Ouen power station of the City of Paris, is particularly interesting. The scheme provides for the feeding of waste gases of a 10MW gas turbine to the combustion chamber of a 150 t/h steam generator, utilising these gases as preheated combustion air. In addition, in this project the boiler feed water is used to cool the compressor of the gas turbine plant. The combined plant is to supply steam to the heating network of the Paris District Heating Company, which obtains steam from several groups of boilers, and takes heat from the waste steam of a 40MW back-pressure turbine. An important advantage of the combined plant is the fact that the gas turbine can be operated independently of steam supply from the boiler, facilitating adaptation to peak load requirements.

(*To be continued*)

Royal Show at Newcastle upon Tyne

No. I

THE annual show of the Royal Agricultural Society of England has no fixed abode. Every year it is staged in a different part of the country, though after an interval it is held again in the same region. Thus, next week the Royal Show makes its seventh visit to Newcastle upon Tyne. It will open there at Town Moor, next Tuesday, July 3rd, and will continue until Friday, July 6th. Next week's show is the 108th to be held, and it will be the tenth since the resumption of the show following the second world war. The show ground occupies about 156 acres, and a further 120 acres or so have been set aside for car parks.

As Newcastle upon Tyne is the most northerly point at which the " Royal " has been held since the war, it is interesting to recall some of the occasions previously on which the show has taken place there. The last time was in 1935, when the mechanisation of agriculture was proceeding at a much more leisurely pace than in the years which followed. In 1935, the North-East Coast was still suffering from industrial depression, and agricultural costs were high in relation to production. We noted at the time that considerable emphasis was given at the show to the application of electricity to agriculture, and we also reported that there were very few entries of new implements and machines for the Royal Agricultural Society's silver medals. Other shows have been held at Newcastle in 1846, 1864, 1887, 1908 and 1923, that of 1908 drawing a record attendance, on one of the days, of 98,489. The first of the Newcastle " Royals," in 1846, was ten years before this journal came into existence. The second, in 1864, was of significance in that prizes of £100 and £50 were offered for the " best application of steam power to the cultivation of the soil."

Our principal comment about the show at Newcastle in 1864 was that " a glance at the array of coughing engines and gliding implements tells us that the old notion of a locomotive dragging a plough at its tail is completely exploded, and we perceive no longer any attempt to embody in mechanical parts that other and more philosophical idea of a locomotive delving the soil by revolving blades." Incidentally, both the prizes offered at Newcastle in 1864 by the Royal Agricultural Society were won by Mr. John Fowler, of Leeds. We reported that John Fowler's 14-horse engine, with clip drum under the boiler, a travelling anchorage pulley at the opposite headland, and a four-furrow balance plough, made some good work at a depth of 6in, the rate of performance being about 5 acres a day of ten hours, and the coal burnt 214 lb per acre. The " hands engaged were three men and two lads." In recalling this occasion, it is appropriate to mention that eight years earlier, just 100 years ago, John Fowler took part in the first competition organised by the Royal Agricultural Society for " the best application of steam power to the cultivation of the soil." Agricultural mechanisation has made tremendous strides since then, but there will no doubt be some visitors to Newcastle next week who will compare the day of steam power in agriculture with the present, in which the resources of the internal combustion engine are more than ever manifest on the land.

The machinery and implement section of this year's show, which is of course our particular interest, will be as extensive as ever. Here and there on the 600 or so stands visitors will be able to see examples of new equipment, and they will find new models and developments of existing machines and implements. But a study of the advance information made available to us gives us the impression that the major portion of the machinery exhibits will be familiar to those who regularly attend the Royal Show. That does not necessarily minimise the interest or importance of the display. To be able to see in one place the great array of equipment now manufactured for use on farms in this country and overseas emphasises, perhaps better than anything else, the worthwhile contribution that engineers continue to make to a highly mechanised agriculture.

The new equipment is mainly—though not wholly—that which is entered for the Royal Agricultural Society's silver medals. The medals are awarded for implements or machines " adjudged to be new in principle or purpose." This year, thirty-four entries were submitted, and seventeen of them were accepted by the Society for adjudication, subject to test reports being available prior to the show. There are also three entries for judging which were deferred from last year. Of these twenty " silver medal " entries, it is probable that one or two will be deferred in order that further tests may be made on them. We have already described in these columns some of the machines and implements which have been put forward this year for silver medals, and we make reference here to some of the others.

One of these machines is a bulb lifter (Fig. 1), which will shown by H. Leverton and Co., Ltd., Spalding, Lincs. It has been designed as an attachment to the Lanz tool carrier, a description of which was given in our issue of December 11, 1953. The engine, a 14 h.p. diesel, and transmission are combined with the back axle, and in front of them there is a rectangular frame which forms the " carrier " for a variety of implements. The arrangement of the carrier is such that the operator has a good forward view of the work. In designing the bulb lifter, the makers have studied the peculiar requirements of the Lincolnshire bulb growing industry ; it is essential, for example, to raise the bulbs from the soil undamaged. The machine includes a disc coulter and plough, the mould board of which skims off the top 2in or 3in of soil before the lifting share comes into action. The soil and the bulbs are then taken up by a plated conveyor on to a spring-loaded slatted conveyor. Both soil and bulbs are deposited on a shaker riddle hung transversely across the machine ; the soil is sifted through the riddle and the bulbs are deposited clear of the " lifting line." The depth of the lifting share can be controlled from the operator's seat and the machine is driven by the power take-off shaft which is part of the standard equipment of the tool carrier.

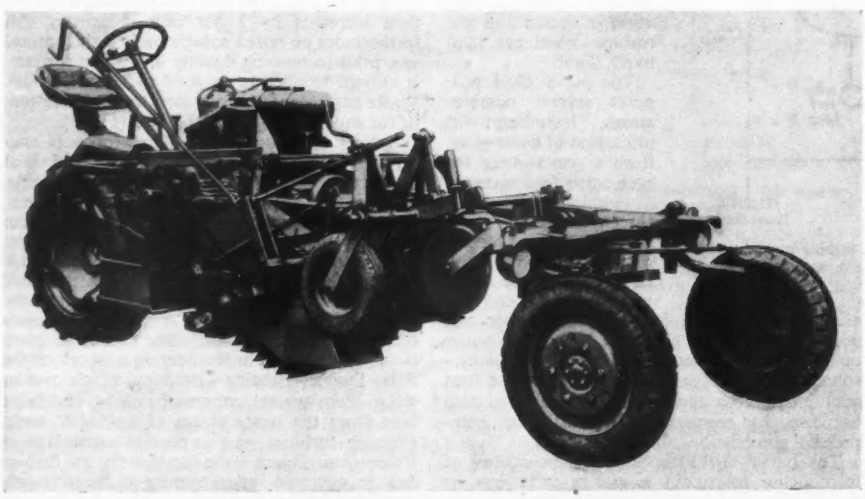


Fig. 1—Machine for lifting bulbs, designed for attachment to the Lanz tool carrier

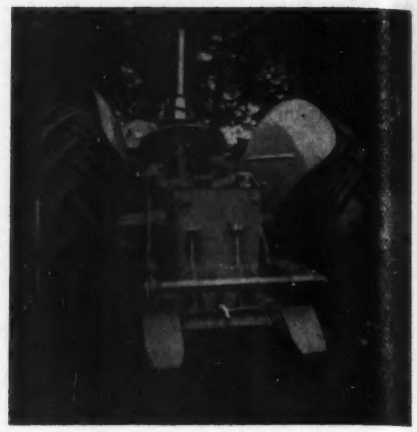


Fig. 2—Tractor-operated winch with drum capacity of 75ft

Another silver medal entry is a tractor operated winch (Fig. 2), which is to be exhibited by T. T. Boughton and Sons, Ltd., Amersham Common, Bucks. The winch, which is designated the " SW," is constructed of steel throughout and fits conveniently between the three-point linkage of a tractor. It is equipped with a self-energising brake, and, as our illustration shows, there is an underslung anchor which is lifted by the tractor's hydraulic system. The drum capacity of the winch is 75ft of $\frac{7}{16}$in diameter wire rope and a line pull of 12,000 lb can be obtained. By using a castor attachment which the firm supplies, the " SW " may be employed for front as well as for rear winching.

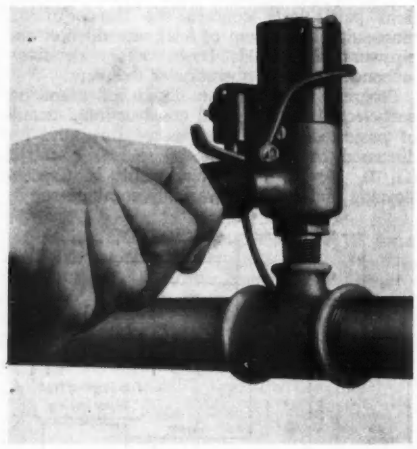


Fig. 3—Stall tap for the " Pulsomatic " milking system

Dairying is now as highly mechanised a business as arable farming. There are fewer and fewer farms which rely upon hand milking, and the show, as usual, will include a display of milking machinery and other dairy equipment. One of the silver medal entries is the " pulsomatic " system devised by R. J. Fulwood and Bland, Ltd., Ellesmere, Salop. The pulsator on a milking machine consists basically of a

valve or valves connecting the space between the teat cup shell and the rubber liner alternately with atmospheric pressure and reduced pressure ; conventionally a pulsator is operated by vacuum. An electro-magnet, by providing an intermittent current, can operate a valve to perform the same function as does the vacuum in a normal pulsator. The Fulwood system eliminates the pulsator from the lid of the milk bucket, and by combining the pulsator with the stall tap, as shown in Fig. 3, gives a " pulsating " tap which is fully automatic and which operates only when the milking unit is attached. As this pulse tap is fixed in the pipeline, the electro-magnet can be made big enough to give correct pulsations to the teat cups by using a single stall tube and without a relay on the lid of the milk bucket. A master control box supplies an intermittent current to a low-tension wire on the pipeline ; as all the electrical connections are incorporated in the pulse tap, no part of the actual milking unit is connected with the electricity supply.

Although mechanisation has made such rapid progress in the field and on the farm, there are some tasks which continue, for the most part, to be done by hand. In recent years the preparation of silage for cattle feeding has assumed an increasingly important place. But the cutting of silage by hand is a very arduous task which cannot be done very speedily. The silver medal entry of Atkinson's Agricultural Appliances, Ltd., Clitheroe, Lancs, has been designed to deal with this problem. It is a power-operated cutter known as the " Silo-Aid " (Fig. 4). This tool, which can be used for cutting silage, peat or farmyard manure, incorporates an oscillating blade driven by a ½ h.p. a.c. motor, or, alternatively, by an 80 c.c. petrol engine. When the blade has reached its full depth of about 8in, a slight rocking movement by the operator is sufficient to inch the machine along in the direction of the desired cut. The blade is designed to cut a straight face and square cut, and the makers say that during tests the tool has cut to the full depth at the rate of 12ft a minute. The model illustrated is that which can be operated from the normal electricity supply. Its weight, like the petrol-engine-driven model,

Fig. 4—Mains-operated silage cutter

is 47 lb. An on-off switch is placed conveniently near to the handle, and there is a trip device which protects the motor from overload.

Among the tillage implements, accepted as silver medal entries, there is a tractor-drawn fertiliser distributor which is to be shown by Onneley Implements, Ltd., Woore, near Crewe. This machine, which is called the " Cooper Limemaster," consists essentially of twin hoppers which run on rails mounted on a steel chassis. A single balloon-tyred castor wheel at the back

Fig. 5—Tractor driven chopper for straw cutting. Its working width is 6ft

of the machine ensures that the main weight is taken by the back wheels of the tractor, the mounting of the " Limemaster " being accomplished by bolted hinges below the tractor's back axle. When closed for loading and transport, the hoppers have a width of 8ft ; they can be moved along the rails, by a winding system, to give a spreading width of 14ft. The fertiliser is fed by gravity through spaced apertures in the bottom of the hoppers, and there are revolving agitators to assist the feed. The drive is taken by sprocket and chain from the back wheel of the tractor to a shaft which rotates the agitators, and within the hoppers screens are fitted to prevent any damage by stones. Incidentally, the greasing points throughout this machine are easily accessible.

Turning now from the items which are to be judged for the Royal Agricultural Society's silver medals, we illustrate in Fig. 5 a machine for chopping straw and clearing bracken or similar vegetation. The original version of this machine, the Wilder-Rainthorpe chopper, was adjudged the best of the new implements at last year's Royal Show. The machine is made by John Wilder, Ltd., Wallingford, Berks. The model which will be shown at Newcastle is bigger than the original and has a cutting width of 6ft. The machine consists of a two-wheeled, channel-section steel chassis on which there is mounted a chopping rotor fitted with two banks of swinging tines. These tines are arranged so that they pass between two banks of fixed knives attached to the chassis. The straw is picked up from the swath by the rotor tines as the machine travels forward, and is chopped as it passes between the swinging tines and fixed knives. As a straw chopper, the machine is used in the wake of a combine-harvester where it is not required to bale straw. Chopped straw decomposes quickly and can be easily ploughed in. In the new version, however, the use of the Wilder-Rainthorpe chopper has been extended. It can be employed for pasture topping by replacing the straw chopping tines by cranked tines ; to deal with tougher material such as potato haulm, kale stalks and bracken, tines of different lengths are fitted, and for this application row crop wheel attachments are available. To change the machine from straw chopping to pasture topping, the two pivot bars which hold the rotating tines are unbolted and slid out. The set of replacement tines is threaded on to these bars as they are slid back into position. The removal of four bolts permits the bottom row of fixed knives to be taken off the machine. The rotor and knives are enclosed at the front, top and sides by a shield, and there is a sheet steel flap hinged to the rear edge of the shield above and behind the rotor. The angle of this flap is adjustable vertically to alter the distance that the chopped material is thrown behind the machine. Attached to the underside of the flap there are two adjustable metal deflectors, and by altering the setting of these deflectors the degree of lateral spreading of the chopped material can be varied. The rotor is driven from the power take-off shaft of a tractor, through a gearbox, countershaft and pulleys and vee-belts.

(To be continued)

Books of Reference

The Electrical Trades Directory (*The Electrical Journal Blue Book*), 1956. Edited by Norman H. Codling. Benn Brothers, Ltd., 154, Fleet Street, London, E.C.4. Price 63s.—Many sections of this classified electrical trades directory have been expanded, including those giving the names of manufacturing companies and products and materials. Generally the format remains unchanged and there are sections of the directory devoted to electricity supply, transport, installation contractors, wholesalers and distributors, exporters, importers, and patent agents, institutions and societies and trade associations. To simplify reference there is a complete alphabetical index from which the appropriate section of the directory can be found.

The Abridged Building Classification (ABC), 1955 Edition. British Standards Institution, 2, Park Street, London, W.1. Price 23s. 6d.—This volume consists of a schedule of numbers, selected from the Universal Decimal Classification as especially applicable to architecture, building and civil engineering, together with explanatory notes on the use of the system. The schedule has been developed by the International Building Classification Committee over five years from the Ministry of Works library abridged schedule. Fifteen countries are represented on the committee. The *Abridged Classification*, while in full accord with the U.D.C. is in a handy form for use in architects' and builders' offices as well as by specialist building libraries, for filing information. Translations into ten other languages are in preparation for publication in identical format.

The British Shipbuilding Compendium, 1956. Sixth edition. The Shipping World, Ltd., Effingham House, Arundel Street, Strand, London, W.C.2. Price 20s.—This compendium is a completely revised version of the fifth edition, which was issued two years ago, and has been carefully rearranged to give a better classification and to cover new developments. However, as in previous editions, the book lists the many companies which supply materials and equipments to the marine industry and also the shipbuilders and ship repairers. There are four main sections : section " A " is concerned with shipbuilders, ship repairers and dry dock owners ; section " B " lists the manufacturers of main and auxiliary machinery ; section " C " names the suppliers of the wide variety of equipment, fittings, stores, &c., required by the shipbuilding industry, while section " D " covers items of ship yard equipment. Finally, there is an alphabetical index of the firms with a cross reference to the heading under which it is mentioned.

Metallurgical Topics

High-Strength Steels

HITHERTO the most commonly used steel for high-tensile steel parts in American aircraft construction has been S.A.E. 4340, which contains :—

	Per cent		Per cent
Carbon	0·38–0·43	Manganese ...	0·60–0·80
Silicon...	0·20–0·35	Nickel	1·65–2·00
Sulphur	0·04 (max.)	Chromium ...	0·70–0·90
Phosphorus ...	0·04 (max.)	Molybdenum ...	0·20–0·30

and has a tensile strength of 67 to 76 tons per square inch when oil-hardened and tempered at 480 deg. Cent. In seeking to raise its tensile strength still further it is undesirable to reduce the tempering temperature progressively because of the trough of low-impact values in the tempering curve, which precludes tempering within

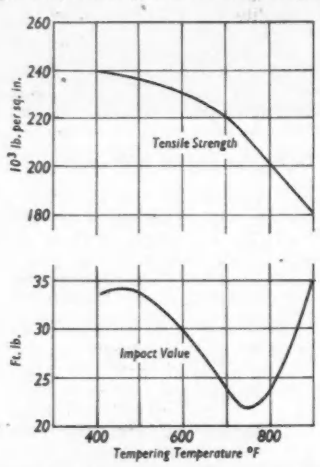


Fig. 1—Effect of tempering temperature on the tensile and impact properties of 1in diameter bars of "Hy-tuf" steel oil-hardened from 858 deg. Cent

the approximate range 250 deg. to 400 deg. Cent. Mr. P. M. Mozley,[1] chief metallurgist of the Lockheed Aircraft Corporation, has described how the tensile strength of this steel can be raised to within the range 116 to 125 tons per square inch, while still avoiding undue brittleness, by lowering the tempering temperature to between 200 deg. and 260 deg. Cent., according to the hardness of the steel as quenched, and taking extreme precautions in further fabrication; but he gave 300,000 lb per square inch (134 tons per square inch) as the requirement of the immediate future.

Further attempts made in America to raise the useful strength of important steel components of aircraft structures from 200,000 lb to 300,000 lb per square inch have been described by J. W. Sands and O. O. Miller[2] of the International Nickel Company, Inc. Attainment of more than 115 tons per square inch (min.) in S.A.E. 4340 by reduction of the tempering temperature is regarded as undesirable on account of dangerously high unrelieved stresses which cause an unacceptable loss in yield strength, ductility and impact value. Reduction of the carbon to 0·3 per cent with the addition of 0·08 per cent of vanadium gave improved impact values at tensile strengths of 100 to 110 tons per square inch, but the more promising developments were in the direction of change of composition.

EFFECT OF SILICON

This took advantage of the characteristics imparted by silicon, which, as shown by A. G. Allten and P. Payson,[3] retarded softening on tempering in the lower range of tempering temperatures. The first steel of this kind which received recognition in America was "Hy-tuf", developed by the Crucible Steel Company of America and containing :

	Per cent		Per cent
Carbon	0·25	Nickel	1·83
Silicon	1·50	Chromium	0·30
Manganese	1·35	Molybdenum	0·40

This steel could be oil-quenched and tempered at 315 deg. Cent. to give hardness and tensile strength equal to those of a similar steel with normal silicon content tempered at a lower temperature, and a much better impact figure. Silicon raises the tempering range which gives low impact values, the minimum being obtained on tempering at 410 deg. Cent. (Fig. 1). "Hy-tuf," oil-quenched and tempered at 315 deg. Cent., has a tensile strength of 103 tons per square inch and an impact value of 30ft-lb. This composition was one of those investigated by C. H. Shih, B. L. Averbach and M. Cohen,[4] who found that the presence of 1·5 per cent of silicon in the steel, hardened and tempered at 260 deg. Cent., raised the tensile strength from 97·5 to 108 tons per square inch without loss of ductility, the Charpy V-notch impact value being 26·5ft-lb.

It was evident that to increase the tensile strength to the extent desired a higher carbon content was necessary, and the tendency was to revert to the carbon and chromium content of the original nickel-chromium-molybdenum steel.

TRI-CENT STEEL

The development dealt with mainly in Sands and Miller's article is the steel known as "Tri-cent" (the name implying a 300,000 lb per square inch tensile strength) having the composition :

	Per cent		Per cent
Carbon	0·43	Nickel	1·83
Silicon	1·60	Chromium	0·85
Manganese	0·80	Molybdenum	0·38
		Vanadium	0·08

This also was a steel investigated by Shih, Averbach and Cohen, who found that it gave the same properties after tempering at 370 deg. Cent. as did a similar steel with normal silicon content after tempering at 200 deg. Cent., and that the high-silicon steel, tempered at 260 deg. Cent., showed an increase in tensile strength from 116 to 134 tons per square inch with no reduction in the impact figure of 15ft-lb.

The results of tests made on Tri-cent steel from a 7-ton electric furnace heat of aircraft quality made by the Bethlehem Steel Company, are shown in Fig. 2. Maximum yield strength and

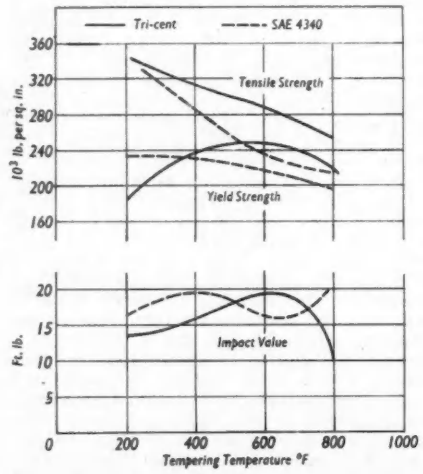


Fig. 2—Effect of tempering temperature on the tensile and impact properties of 1in diameter bars of S.A.E. 4340 and "Tri-cent" steels oil-hardened from 858 deg. Cent

resistance to impact were reached simultaneously by tempering in the range 260 deg. to 315 deg. Cent. Results of tests on butt-welded tubes, 5½in diameter by ¼in wall thickness, of "Tri-cent" are given in Table I. Data on five different steels in the form of large landing gear forgings, commercially heat-treated, have been obtained by the Wright Air Development Centre. Strengths of very nearly 300,000 lb per square inch were obtained ; these results also are shown in Table I.

The risks and limitations in manufacturing operations involved in the use of these high-strength steels were clearly set out in the paper by P. M. Mozley, already referred to, and they are not overlooked by Sands and Miller. Factors which constitute hazards include the sensitivity of the steel to hydrogen embrittlement and to damage in grinding, and the adverse effect on the endurance limit in fatigue of any surface decarburisation produced during heat-treatment. Difficulties are also encountered in welding, machining and other forming operations. Emphasis is placed on the need for careful handling and meticulous inspection all along the line and particularly for every effort to minimise notch effects and other stress raisers.

TABLE I—*Properties of Oil-Hardened and Tempered "Tri-cent" Steel*

	Tubes		Forgings	
	Tempered at 400 deg. Fah. (204 deg. Cent.)		Tempered at 500 deg. Fah. (260 deg. Cent.)	
	Parent metal	Across weld	Longi-tudinal	Trans-verse
0·2 per cent yield strength, lb/sq. in.	—	—	242,000	239,000
Tons per sq. in.	—	—	108	107
Tensile strength, lb/sq. in..	302,500	285,600	297,000	296,000
Tons per sq. in.	135	127·5	132·5	132
Elongation, per cent ...	9	3	8	4
Reduction of area, per cent	18	7	23	9
Charpy V-notch impact value, ft-lb :				
At room temperature...	20	19	18	9
At −65 deg. Fah. ... (−54 deg. Cent.)	18	14	15	7

[1] *Metal Progress*, July, 1955, page 78 ; THE ENGINEER, August 26, 1955, page 299.
[2] *Materials and Methods*, March, 1956, page 94.
[3] *Trans. Am. Soc. Metals*, 1953, Vol. 45, page 498.
[4] American Society for Metals, 1955, Preprint No. 9.

Growth of an Austenitic Cast Iron

CHANGES in the form and dimensions of grey cast iron on heating or exposure to fluctuations of temperature are attributed to the decomposition of cementite, oxidation and crack formation due to alternate heating and cooling through the eutectoid temperature. The last two causes are related inasmuch as oxidation becomes of greater account when cracks are present, and since these are produced mainly by heating and cooling through the A_1 point, oxidation is greater in specimens exposed to fluctuations of temperature above and below A_1 than in those subjected to a long annealing above A_1.

Austenitic cast irons are generally less affected by heat and oxidation, but growth also occurs in austenitic cast iron. The causes of change in dimensions and in other properties have been investigated by W. Heinrichs and A. Dahlmann* in a non-magnetic cast iron containing carbon 3·45 per cent, silicon 3·30 per cent, manganese 12·8 per cent, nickel 7·59 per cent, phosphorus 0·18 per cent, and sulphur 0·01 per cent, cast in the form of cylindrical bars 700mm long and 35mm in diameter. Changes in length, volume and weight were measured on specimens 100mm in length and 30mm in diameter after long-time annealing for up to 650 hours at a steady temperature, and after twenty alternations of heating and cooling, the temperatures employed being 300 deg., 450 deg., 550 deg., 600 deg., 650 deg., and 750 deg. Cent. in air, and 550 deg. and 750 deg. Cent. in nitrogen. Up to 300 deg. Cent. (or higher) there was no permanent change in dimensions. There was no change after long annealing at 450 deg. Cent. and only 0·005 per cent increase in length after alternate heating and cooling. There was an increase in length of 0·13 per cent after twenty alternations between 550 deg. Cent. and room temperature, and of 0·4 per cent after 650 hours at that temperature both in air and in nitrogen, but the increase in weight was 0·084 per cent in air and 0·048 per cent in nitrogen. After 690 hours at 750 deg. Cent. in air the increase in length was 0·82 per cent, in nitrogen 0·43 per cent ; the corresponding increases in weight being 2·15 per cent in air and 1·09 per cent in nitrogen. On the other hand, alternate heating to 750 deg. Cent. and cooling to room temperature produced no change in dimensions, indicating that at this temperature the cause of growth was associated with prolonged

* *Technische Mitteilungen Krupp*, December, 1955, page 147.

annealing. A reduction in the effect of alternate heating and cooling was already noticeable on comparing results after treatment at 550 deg. Cent. with those obtained at 600 deg. and 650 deg. Cent. The effect twenty cycles of heating and cooling between these temperatures and room temperature gave almost identical increase in length of about 0·08 per cent.

Changes in magnetic properties caused by these annealing treatments were also examined. It was found that this almost non-magnetic cast iron became magnetic after heat-treatment. The magnetic saturation reached its greatest value after annealing at 550 deg. Cent., whereas the coercive force showed a maximum after annealing at 450 deg. Cent. To obtain the lowest coercive force as well as the lowest magnetic saturation it appeared desirable to increase the nickel or manganese content in order to diplace the eutectoid transformation to a lower temperature.

As a result of these measurements and of a study of the structural changes revealed by the visual and electron microscopes and of determinations of oxygen content in surface layers, it was concluded that the causes of growth in this austenitic cast iron were, apart from oxidation, different from those applicable to ordinary grey cast iron. Decomposition of carbide and crack formation due to passing through the A_1 temperature (important causes in pearlitic irons) do not occur in austenitic iron. On the other hand, the causes of growth are given as :—

(1) The transformation of austenite to pearlite (at temperatures below 600 deg. Cent.).

(2) The separation of carbide from austenite (at temperatures above 600 deg. Cent.).

(3) Oxidation.

(4) The transformation of austenite and graphite to carbide at 750 deg. Cent. The carbide formed did not correspond to the formula $(Fe,Mn)_3C$, but clearly had a considerably lower carbon content.

In both sorts of iron surface oxidation may occur to an extent dependent on the composition and on the form of the graphite. It may be suggested that oxidation was rather more pronounced in this high manganese austenitic cast iron than it would be in other specimens having lower silicon and graphite contents, or in some other austenitic cast irons.

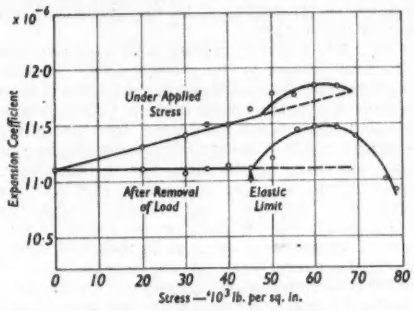
Effect of Stress on Thermal Expansion

A METHOD of measuring coefficient of expansion as well as determining Young's modulus and elastic limit has been developed by A. R. Rosenfield and B. L. Averbach,* and has been applied by them to the measurement, under tensile stress and after the stress has been removed, of the expansion coefficients of three hardened and tempered steels (carbon 0·20, 0·41 and 0·82 per cent) and two samples of Invar (the ordinary type containing 36·4 per cent of nickel, and the free-cutting type with the addition of 0·23 per cent of selenium).

Tensile specimens, 0·252in diameter, gauge length 2in, were employed. Electrical resistance strain gauges were attached on opposite sides with "Duco" cement and bound with insulating tape. Strain gauges were similarly applied to dummy specimens of the same material and heat-treatment, and to bars of Invar whose expansion coefficients had been measured by an optical method and found to be zero. The specimens, dummy and Invar standard were all contained in a double-walled can filled with silicone oil, which was part of the linkage of a dead-load testing machine. The temperature of the bath was controlled by an immersion heater and a cooling coil, and measured to 0·1 deg. Cent. Expansion under no load was determined by adjusting the bath temperature to 13 deg., 18 deg., 23 deg. and 28 deg. Cent. and comparing the strain gauges with those on the Invar standard. A known load was then applied to the test bar and the same procedure followed. The load was removed, the residual strain observed and the expansion coefficient measured again at no-load.

Typical results for steel, obtained with the sample containing 0·2 per cent of carbon and 0·89 per cent of manganese, are illustrated. The expansion coefficient increased linearly with stress up to the elastic limit ; then the increase was discontinuous. So long as the elastic limit was not exceeded, the expansion coefficient on removal of the load returned to its original value ; but after being stressed beyond the elastic limit the unloaded specimen showed an increased coefficient which passed through a maximum as the load which had been applied increased.

The expansion coefficient of Invar (in contrast with that of steel) decreased under tensile load



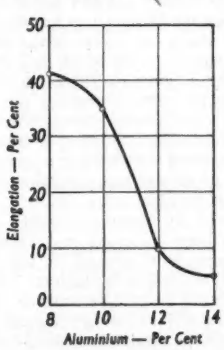
Effect of stress on the coefficient of expansion of 0·2 per cent carbon steel

until the elastic limit was reached, but returned to its original value after removal of the load. Beyond the elastic limit a similar discontinuity was observed in Invar and in steel.

The conclusion was reached that when the applied stress was below the elastic limit, the change in the expansion coefficient (α) with stress (σ) was given by $(\delta\alpha/\delta\sigma)_T = -1/E^2(\delta E/\delta T)_\sigma$, where E = Young's modulus and T the temperature ; if the stress was removed the expansion coefficient returned to its original value. When the applied stress exceeded the elastic limit, there was a discontinuous change in the expansion coefficient and its value on reloading differed from its original value. The lattice distortion associated with even slight plastic strain (2×10^{-6}) appeared to be sufficient to change the expansion coefficient both under load and after the load was removed.

Iron-Aluminium Alloys

IRON-ALUMINIUM alloys to be resistant to oxidation up to 1000 deg. Cent. must contain upwards of 8 per cent of aluminium, but the tensile elongation and notched bar impact value of the forged and annealed alloys with more than 5 per cent are usually very low. This lack of ductility has retarded the use of these alloys and led to the development of various methods for



Elongation of vacuum-melted iron-aluminium alloys (Morgan and Zackay)

coating or impregnating a steel surface with aluminium to improve corrosion resistance at normal temperatures or to render the material immune from scaling or from attack by furnace flue gases containing sulphur.

One factor contributing to the embrittlement of the iron-aluminium alloys is their large grain size. Alloys with more than 1·2 per cent of aluminium are ferritic at all temperatures and undergo no allotropic change whereby a refinement of grain size is brought about. Grain refinement, for example, in wire drawing, can only be produced by reductions at successively lower temperatures. In this way, C. Sykes and J. W. Bampfylde[1] improved the elongation of the annealed 7 per cent aluminium alloy from 5 per cent to 32 per cent.

The brittleness of the early iron-aluminium alloys was, however, attributable mainly to the presence of impurities, chiefly oxide. The use of protective slags and high-frequency furnace melting led to a considerable improvement, and this has been followed up by E. R. Morgan and V. F. Zackay.[2] By melting in zirconia crucibles under a high vacuum they were able to make alloys containing up to 17 per cent of aluminium, though room-temperature brittleness and ingot unsoundness remained a problem at this high aluminium content. The sharp drop in elongation, which occurred in earlier alloys at about 5 per cent of aluminium, was, however, now transferred to about 10 per cent of aluminium, and reasonable ductility was obtained in alloys resistant to oxidation up to 1100 deg. or 1200 deg. Cent. Carbon content is a factor causing erratic results, but a carbon content of 0·03 per cent (maximum) is said to have aided efficient deoxidation. Higher carbon begins to impair ductility and with 0·15 per cent of carbon cold working became difficult.

Extension of vacuum melting technique to high-chromium iron-chromium alloys (which are also ferritic at all temperatures) has already been shown to be beneficial ;[3] and, in due course, iron-aluminium alloys will benefit by further development of this method of melting and refining ferrous alloys.

REFERENCES

[1] *Journal of the Iron and Steel Institute*, 1934 (2), Vol. 130, page 389.
[2] *Metal Progress*, October, 1955, page 126.
[3] *Metal Progress*, October, 1953, page 103.

Zinc Alloy Die Materials

SAND cast zinc alloy dies are used for forming, flanging and bending operations in the sheet metal industries. Unalloyed zinc was at one time used, but later zinc alloys were found to be superior, and to be capable of producing ten to fifty times as many stampings as were obtained from unalloyed zinc. The alloys with the greatest hardness were the best. Widely used alloys are Mazak 2 (Al 4, Cu 3, Mg 0·03, remainder high-grade zinc), and Mazak 5 (Al 4, Cu 1, Mg 0·04, remainder high-grade zinc). As many of these dies have to be stored for the manufacture of replacement parts, Mazak 5, with its greater dimensional stability, may prove to be more desirable than Mazak 2, even though fewer stampings can be made from it before failure.

There is, however, a considerable gap between the number of stampings obtainable from a zinc alloy die and a ferrous metal die, and therefore a demand exists for low-cost zinc-base dies of longer productive life. Developments made by General Motors Overseas Operations (G.M.O.O.) to meet this requirement are described in an article by J. C. Holzwarth and A. L. Boegehold.* Trials were made by adding to the zinc alloy aluminium-silicon in sufficient amount to give at least 0·6 per cent of silicon in the final product. The hard particles of silicon, precipitated owing to the fact that silicon is not soluble in zinc, increased the wear resistance of the dies, but there was difficulty in obtaining homogeneous castings. The hardener which was finally selected to replace the low-density silicon was a combination of nickel and titanium, added to the zinc as a ternary alloy of copper, nickel and titanium. The copper-rich phase is selectively dissolved, leaving solid particles of the nickel-titanium phase, probably Ni_3Ti, suspended in the zinc-base melt. The density of these particles is very similar to that of the alloy, and when the melt solidifies they are trapped and firmly held in the matrix. An optimum combination of wear resistance, castability and cost was obtained in an alloy of approximate composition : Al 4 Cu 3·25, Ni 0·8, Ti 0·2, Mg 0·15, and balance zinc. This alloy, to which G.M.O.O. has given the name "Gmoodie," has a melting point of about 400 deg. Cent. and a Brinell hardness of 100 to 110. Alloying procedure is described and estimates are given of the relative costs of conventional zinc-base alloy dies, "Gmoodie" dies and iron dies used to produce panels for a refrigerator. It is stated that, on similar dies, four times as many pieces can be formed on "Gmoodie" as on the conventional zinc-base alloy.

* *Journal of Applied Physics*, February 1956, page 154.

* *Metal Progress*, May 1956, page 49

Centenary of Gilbert Gilkes and Gordon, Ltd.

HOW difficult it often proves to decide exactly when a firm was founded. Sooner or later the year approaches during which a centenary should be celebrated ; and it would be pleasant to be able to select an exact date and to be able to say, to-day, precisely one hundred years ago, this firm came into business. Sometimes it is possible ; more often not. For every man works for his living doing something. Out of that work at some stage there begins to grow something bigger and less individual than a one-man business. But it is often impossible to fix a date. Under those circumstances all that can be done is to pick upon some particular event and regard it as corresponding to the foundation of the firm. For example, the acquisition of new premises or the receipt of the first order for a particular kind of machine may be chosen. That is what Gilbert Gilkes and Gordon, Ltd., has done in choosing to regard 1956 as its centenary year.

Over a hundred years ago two brothers by the name of Williamson are known to have been operating a small ironworks at Stainton, some 4 miles from Kendal in Westmorland. But how long that business had been operating is not known. Perhaps it had so prospered that the brothers felt they could branch out a bit, or alternatively they had become ambitious to extend their business. At any rate, in April, 1856, it is on record that the Kendal Town Council agreed to let them have a twenty-one year lease of certain canal warehouses in the town. These warehouses marked the termination of the Lancaster and Kendal canal and after their erection in about 1819 had been used for the loading of canal barges with wool under cover. The return traffic was coal ; and when the railway had drawn away the wool traffic from the canal, the warehouse and its covered loading bay served no purpose as the coal still carried on the canal could be unloaded in the open.

On August 5, 1856, the lease was finally signed. Thereafter the loading bay was filled in and the warehouse became the works of Williamson Brothers. On August 17th, of the same year, the new firm received an order for a 5 h.p. water turbine operating under a head of 31ft. Thus, in August of that year, Williamson Brothers not only started work in Kendal but started also to build a type of machine for the design and construction of which the firm was destined to become very widely known. Though no precise date can be fixed, it is reasonable to assume that some time between April, 1856, when the local council agreed to the lease, and August, 1856, when the lease was signed and the first turbine order was received, a new firm came into existence.

But though water turbine No. 1 was built by the firm in 1856, many years had to pass before the business settled down to specialise upon the making of water turbines and pumps. To begin with its manufactures were much more catholic. The Williamson brothers were prepared to make steam engines and saw benches and machinery in general for agricultural and estate purposes. They were primarily local general engineers, ready to try their hands at making anything locally required. Naturally, the locality being favourable to the development of water power, they continued to build water turbines. Turbine No. 1 had been ordered for driving agricultural machinery ; it still exists ; and it is still used occasionally for the same purpose. No. 6 now supplies electric light for a nearby country house. No. 330, a number which shows how important a part of the business this kind of manufacture formed, was supplied in 1876, and still runs every day, driving a diamond saw and lighting generator at Skelwith, not far away in the Lake District.

But though primarily local the business was not wholly so. It is notable, for example, that turbine No. 120 was exported to Australia as early as 1865 and quite a number of turbines and pumps continued to be exported thereafter. The work of the Williamson brothers was by no means wholly restricted to the neighbourhood of the parish pump !

By 1881, probably having done very well out of their business, the Williamson brothers seem to have decided that the time had come to retire. Presumably they had no young people to whom they could hand it on, for they sold it outright to Mr. Gilbert Gilkes, who altered not only the title of the firm but its character. Undoubtedly it is due to this man that the firm ultimately acquired its present world-wide reputation. For he foresaw no future in the general engineering side and he began progressively to concentrate on the manufacture of water power machinery and pumps. Presumably he also brought in more capital. For he enlarged and improved the works and he purchased the water power business of Mr. C. L. Hett, of Brigg, and began the manufacture of Pelton wheels. Slowly but surely thereafter the business expanded. But for some years still the work continued to centre around the old warehouse building in which it was begun. Not until 1908 did it become necessary to erect a new fitting and erecting shop. In 1920 a new foundry became necessary and in 1934 the old foundry was partly converted into a test shop. By 1937 it had become necessary to buy up buildings close by which had been used by another firm as an iron foundry. These were converted into a pattern shop and stores. After the war further considerable extensions were made. Two new main fitting and machine shops much more spacious than those they replaced were added and subsequently a new bay was added to the foundry.

But through all the changes the old warehouse continued to serve a useful purpose. It now forms the main office block and within it there still remain traces of its original purpose. The blocked-up arch through which the canal barges entered it is still there ; and quite recently, when alterations were being made, traces were found of the old hay-racks from which the barge or warehouse horses were fed.

Meanwhile, while expanding the works, the firm had been expanding its business in other ways. In 1928 it purchased the water power connection of James Gordon and Co., Ltd., and it was at that date that the firm acquired its present title. Later the water power connections of Carrick and Ritchie of Edinburgh and Gunther and Sons of Oldham, were acquired. In consequence, since the water turbine records of those companies were also acquired, the firm now possesses a quite remarkable collection of drawings and other information which must cover a very high proportion of all the water turbines installed in Great Britain and Ireland.

This record of expansion could, of course, never have been achieved had there not continuously been improvement in the design and construction of the firm's products. It has never set out to build very high capacity plant. The most powerful Gilkes turbine delivers 9000 b.h.p. It operates in the Andes in Bolivia under a head of 2600ft. In this country the largest is a 3600 b.h.p. Francis machine operating under a head of 80ft at Loch Mullardoch in Scotland. The firm has rather set out to supply relatively small machines of high quality but of simple construction. This policy is exemplified in the design of governors. Where a machine is to operate in a remote mine or power station far from railheads or roads it is very desirable that men on the spot shall be able to dismantle and re-set rather than call upon the works to send out an expert.

There is a minor mystery about turbine No. 1 and its immediate successors. It was built under licence from the designs of Professor James Thomson, of Queen's University, Belfast, elder brother of Lord Kelvin. But no record exists to show how the Williamson brothers got into contact with the Professor. It is possible that upon receiving the inquiry for this machine they found that a small stream with a relatively high head was unsuitable for operating a water-wheel such as they may have been accustomed to make and that they wrote to Professor Thomson to find out if he could help.

The first Pelton wheel was built in 1894 to the designs of Mr. Norman Wilson, who became a director in that year and was later chairman. Other designs became available in 1894 when Mr. Hett's business was taken over. In 1919 Mr. Eric Crewdson, who was chairman from 1934 to 1954, and who is still on the board, invented the "Turgo" impulse wheel. Very roughly this can be regarded as a cross between a true Pelton wheel and a Francis turbine. The jet enters the runner from one side at an angle and is discharged from the other. Its specific speed is substantially higher than that of a Pelton wheel and it permits the runner-jet ratio to be as low as 4·4 to 1, thereby virtually eliminating the need to build multi-jet Pelton wheels. It is interesting to note that the firm was amongst the first to adopt the method of making Pelton runners as a single casting, buckets and all, thus eliminating troubles due to buckets working loose.

On the pump side centrifugals have been built from a very early date. Professor Thomson seems to have provided designs for the earlier ones. But the most notable development—again due to Mr. Eric Crewdson—is that of the G.G.G. self-priming pump first produced in 1932. This is a water-ring side-channel pump whose great advantage lies in its rapidity of self-priming. By a coincidence some independent tests on such a pump were given in an article on "Self-Priming Pumps" in last week's issue. The efficiency is not very high but that fact is of little consequence, for the purposes for which it is used. It has found a market for the water-cooling of small marine engines where its self-priming properties are particularly valuable and it is used for the "Giljector" bilge and washdown system for small engine-driven boats. The pump operates manually for washing down, being belt-driven from the engine, and discharges through an ejector to suck out the bilges, so that there is no possibility of the pump suction being blocked by fish scales or other muck. The pumps have found many other applications.

We have great pleasure in wishing Gilbert Gilkes and Gordon, Ltd., increasing and continuous prosperity in its second century of existence, all the more so that its centenary falls due for celebration in the same year in which we celebrate our own.

Technical Reports

The Aerodynamics of the Cooling of Aircraft Reciprocating Engines. A. S. Hartshorn and L. F. Nicholson. R. and M., 2498. H.M. Stationery Office. Price 40s.—This monograph gives an account of the work done on the aerodynamics of cooling at the Royal Aircraft Establishment during World War II. It refers also to information provided by the Bristol Aeroplane Company and overseas sources. The twelve chapters, each dealing with a specific part of the general problem, show the historical progress and indicate the opinions derived.

Plasticisers and Air-Entraining Agents for Concrete. By M. M. Duriez. Sika, Ltd., 82, Victoria Street, London, S.W.1.—This report is an abridged and translated version of the author's paper presented in Paris last February. It gives a general review of admixtures for concrete, stating the reasons and advantages for their use. Shrinkage and cracking of concrete is discussed, but the report principally describes the properties of plasticisers and air-entraining agents and their applications, illustrated by examples of work carried out in the laboratory.

Magnesium Fabricating and Casting. Report of the Technical Assistance Mission, No. 104. The European Productivity Agency of the O.E.E.C. Price 8s.—This booklet records the work of a mission of fifteen Europeans who visited ten plants in the United States to study the melting, casting, forming and welding of magnesium alloys. The principal source of the mission's technical information was the Dow Chemical Company, whose 2-ton melting furnaces are unloaded by centrifugal pumps driven by compressed air. On the subjects of inspection and research, the mission observed marked contrasts between the practices at Dow and in Europe.

LITERATURE

Measurement of Responsibility. By ELLIOTT JAQUES. Tavistock Publications, Ltd., 2, Beaumont Street, London, W.1. Price 15s.

THERE is a natural tendency as experience of human nature grows to become increasingly suspicious about the value of applying simple hypotheses to account for people's actions. The author of this book will, we hope, forgive us if we confess that we remain unconvinced of the truth of the hypothesis put forward. But lack of conviction must not be supposed to imply lack of interest. Indeed, if only because it suggests a new concept of the relationship between a man's impression of his worth and the salary or wage that he is actually paid the book was read with enjoyment. Anyone in an executive position is likely, too, not only to enjoy reading it but to experience the feeling that a new and interesting light has been thrown upon his relationship with those of inferior and superior status in his firm. The hypothesis in short is very far from one that can be dismissed out of hand.

The basic hypothesis put forward is that every man has an innate capacity for performing work at a certain "level" and that the "level" of any job can be measured objectively and precisely by the maximum span of time during which an individual is expected to exercise discretion on his own account until his use of discretion is subjected to review. The "prescribed" content of a job it is held has nothing to do with it, even though departure from a prescribed procedure, as, for example, when a signalman through negligence or for some other reason departs from a laid down routine, may prove disastrous. The responsibility of a night watchman, as another example, is not to be measured by the value of the goods left overnight in his charge, but only by the degree of discretion he is allowed to exercise in varying the pace of his rounds or in other ways. It is further held that innately every man knows what "level" of work he can attain; that the lev l varies with age; and that intuitively men appreciate the "level" of work attained by men in other parts of an organisation than the one in which they work. Furthermore, it is suggested that, again intuitively, men set against any "level" of work a salary and status corresponding to that "level." Going further still it is argued that any man operating at a level below his capacity will—apparently inevitably—struggle to reach a higher level; and that any man operating at a level above his capacity will, besides being inefficient, be likely to be unhappy and possibly open to illness.

Stated boldly in that way the hypothesis may seem far from convincing. But the arguments for it are based upon investigations carried out over a number of years within the Glacier Metal Company by the author; and some of the results of that investigation come so sufficiently close to being conclusive as to demand further investigation preferably in a different organisation so that it can be determined whether they are applicable only to one particular firm or have the wider implications that the author sometimes assumes. Two of the more remarkable factors influencing a reader to take the author's hypothesis seriously are the correlation that has been found between what the author terms the "maximum time-span of discretion" in any job and the wage or salary it carries, and the ability stemming therefrom to predict from an examination of the time-span of a job what salary or wage the holder of the job will expect. Doubt creeps in, however, because the ordinary mortal, it seems, will be unlikely to assess correctly what the time-span of his job is. One cannot help wondering whether this measurement can really be made as precisely as the author suggests.

The latter part of the book discusses in the light of the hypothesis the psychological meaning of "work" and reviews some socio-economic implications. These chapters indicate how valuable could be the application of the hypothesis; but it is first necessary to establish its truth before it can be profitably applied!

Maths Made Easy. By CHARLES SOLOMON. Postlib Publications, Kingsbury, London, N.W.9. Price 10s.

THERE are a number of people who are "bad at mathematics." Some of them even take a pride in their "badness." In many cases the cause can be traced to the teaching of the subject in an uninteresting and uninspiring manner. Nevertheless, some knowledge of mathematics and some competence in its processes are required in most walks of life. Mr. Solomon has written a book to show that mathematics need not be dull; and that once interest has been aroused, it is not difficult for the average person to become proficient in elementary mathematics and to acquire some understanding of the more advanced aspects. It is specifically stated in the introduction that the book is not designed for mathematicians. In fact, the only knowledge required of the reader is familiarity with simple arithmetic and acquaintance with the terminology of elementary geometry. In a matter of a hundred pages a wide field of mathematics is covered, starting with simple algebra and finishing with the first steps of differential calculus. Some indication, both of the scope of the book and of the style of presentation, is given by the chapter headings. They include: "Mathematics and the Football Pools," "Arithmetic in Pictures," "Was Euclid Wrong," "Measuring the Universe," "How Statistics Can Fool You."

The whole book is written in a lighthearted manner; mathematical points are explained with practical illustrations from everyday life; appeals are made to the common sense of the reader. Such subjects as indices, series, binomial theorem, exponential series, imaginary numbers, elementary trigonometry, probability, are all treated very satisfactorily in this way.

The author maintains that mathematics can be "fun" and this theme permeates the whole book. There is, in fact, a final chapter entitled "Simply for Fun," which contains a number of lighter mathematical problems. The solutions are given, as also are the answers to the examples at the end of each chapter. To conclude, there is a list of books recommended for further reading.

This is not a book for the engineer himself, except possibly for the amusement of doing the problems. But it is a worth-while addition to the household library for the benefit of the younger members of the family. It may well evoke an interest and liking for mathematics in a reader unresponsive to orthodox teachings. Does the book justify the title "Maths Made Easy"? There is no doubt that it contains a great deal of mathematics, all of which is presented in an amusing and interesting way. It is, therefore, made easy—Q.E.D.

Bitumen in Hydraulic Engineering. By BARON W. F. VAN ASBECK, M.I.C.E. The Shell Petroleum Company, Ltd., 1, Kingsway, London, W.C.2. Price 26s. 8d.

BITUMINOUS construction is being used increasingly in civil engineering, and novel applications of this material continue to be made. However, many civil engineers have less knowledge of this type of construction (highway engineering excepted) than, for instance, of the use of concrete; hence the present volume will be welcomed, particularly since it deals with bitumen in hydraulic engineering, about which little has been published. The author considers, however, that *Bitumen in Hydraulic Engineering* is a comprehensive reference book, for in his opinion it would be premature to produce a complete textbook at the present stage of development. This seems rather a modest evaluation, as the information presented, though not exhaustive, goes further than would be expected in a work purely for reference.

The types of bituminous products used in hydraulic applications, laboratory tests for them, typical specifications, and similar basic data are given at the beginning of the book. Types of application—i.e. surface applications, soil treatment, revetments and linings, joints, injections and so on—are then discussed, and there are notes on the properties of bituminous mixes and laboratory tests for them.

The second section of the book deals with hydraulic applications generally and of specialised bituminous construction in hydraulic work. The last section, which takes up about half of the book, gives actual examples of the use of bituminous materials in hydraulic engineering, in coast protection, river bank protection, navigation and irrigation canals, dams and maritime works; there are also examples of waterproofing by hot bitumen injections.

Books Received

Robert Hooke. By Margaret 'Espinasse. William Heinemann, 99, Great Russell Street, London, W.C.1. Price 21s.

Effective Supervision. By Milon Brown. The Macmillan Company, New York, 10, South Audley Street, London, W.1. Price 31s. 6d.

Automation: Friend or Foe? By R. H. Macmillan. Cambridge University Press, Bentley House, 200. Euston Road, London, N.W.1. Price 8s. 6d.

Production and Employment in the Metal Trades: The Problem of Regularisation. International Labour Office, 38–39, Parliament Street, London, S.W.1. Price 7s. 6d.

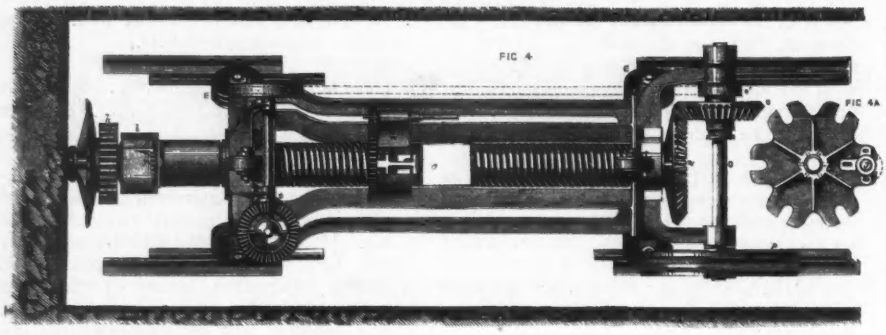
The Design and Construction of Engineering Foundations. By F. D. C. Henry. E. and F. N. Spon, Ltd., 15, Bedford Street, Strand, London, W.C.2. Price 63s.

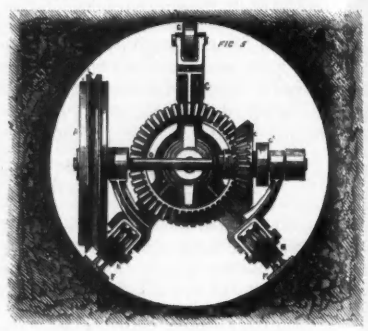
Stability and Trim for the Ship's Officer. Second edition. By John Ladage and Lee van Gemert. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 36s.

Peaceful Uses of Atomic Energy. Vol. 9: Reactor Technology and Chemical Processing. A United Nations Publication. Sales and Circulation Section, Department of Public Information, United Nations, New York, U.S.A. Price 70s.

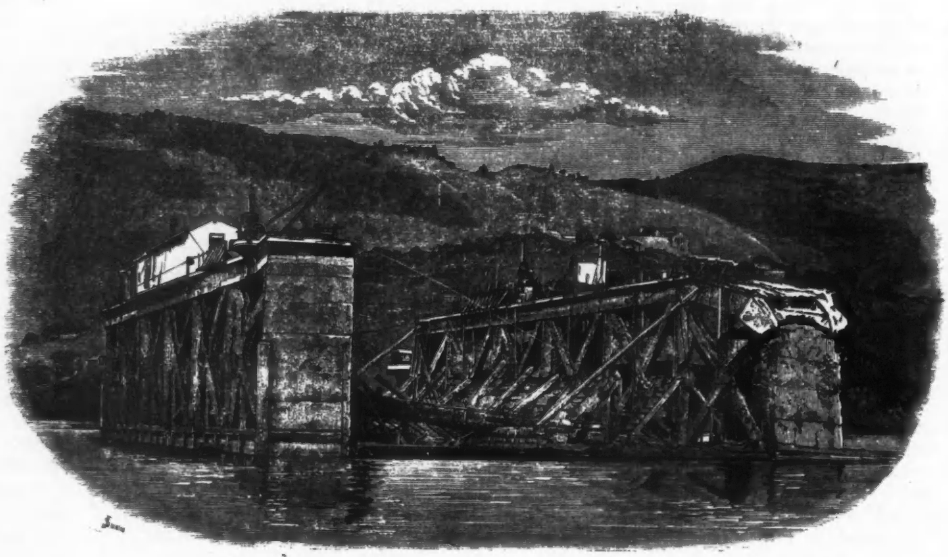
Bibliography on Productivity, Project 233. Prepared by the National Centre of the French Association for the Increase of Productivity and the European Productivity Agency. Published by The European Productivity Agency of The Organisation for European Economic Co-Operation, 2, rue André-Pascal, Paris, 16e. Price 14s.

ENGRAVINGS OF 1871

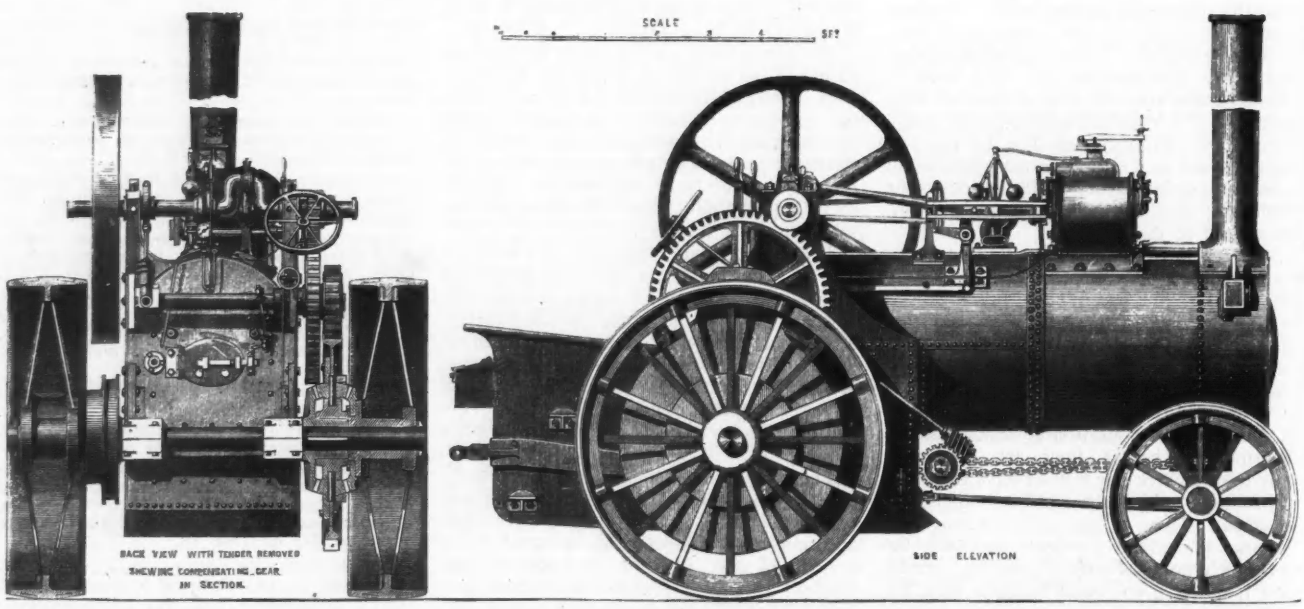




The engraving above, reproduced from our issue of March 24, 1871, shows Brunton's tunnelling machine. This particular machine had two cutter chucks, each of them, with its six cutters, producing its own step. Our article says: "if each takes a step of 1in, a progress forward of 2in will be made by each revolution of the screw shaft. Experience has shown that the cutter chucks may make at least forty revolutions per minute in rock not harder than mountain limestone. Such a speed, with a feed of $\frac{1}{4}$in, gives a progress in the tunnel of 2in in $4\frac{1}{5}$ minutes."



St. Thomas floating dock, illustrated in the right-hand engraving, was designed by Mr. Bramwell and sent out to the "West India Islands" in 1867. Shortly after its completion, the dock was sunk by an accident. Our issue of February 17, 1871, records that the dock "has only recently been recovered by an important engineering feat." The dock was 300ft long and its gross weight was about 3600 tons. Messrs. Wylie and Blaxland, engineers, working in conjunction with Murphy Brothers, professional divers, "undertook to raise the dock for £20,000."



At the Royal Show at Wolverhampton in 1871, there were steam ploughing and traction engine trials. This engraving, reproduced from our issue of June 30, 1871, is of the 10 h.p. traction engine which was entered for the trials by Aveling and Porter (then of Rochester). The engine had a single cylinder 10in bore by 12in stroke, and "in fifty-nine minutes steam was raised to 115 lb on the square inch, 68 lb of coal and 10 lb of wood being consumed in the operation."

International Machine Tool Exhibition—No. II

(*Continued from page 726, June 22nd*)

IN this article we continue our descriptions of some of the interesting machine tools now being shown at the International Machine Tool Exhibition at Olympia.

Newall Engineering Company, Ltd.

Some outstanding developments have been incorporated in the new jig boring machines made by the Newall Engineering Company, Ltd., of Peterborough. One of the new machines, known as the "Spacematic 2657," as can be seen in Fig. 37, is of open-sided design, and has a rapid automatic precision setting and control system which can be actuated by push buttons or by the use of punched cards. The machine has a 26in by 57in table and it is made with two column heights to give from 3in to 31in or from 20in to 48in between the spindle nose and the table, the respective vertical distances from the table to the column throat being 19½in and 36½in. In all other respects the two models are similar.

The quill head has a vertical adjustment of 18in on the column of the machine and the quill itself has a 10in long feed motion, rapid power traverse being available for both these movements. The spindle speeds are steplessly variable between 40 and 2000 r.p.m., a three-speed gearbox providing adequate power in the lower speed range. Spindle speed changing is effected by electro-magnetic clutches and a potentiometer remotely controlled by push buttons. The eight spindle feed rates from 0·0005in to 0·012in per revolution in each direction of travel are selected through a gearbox.

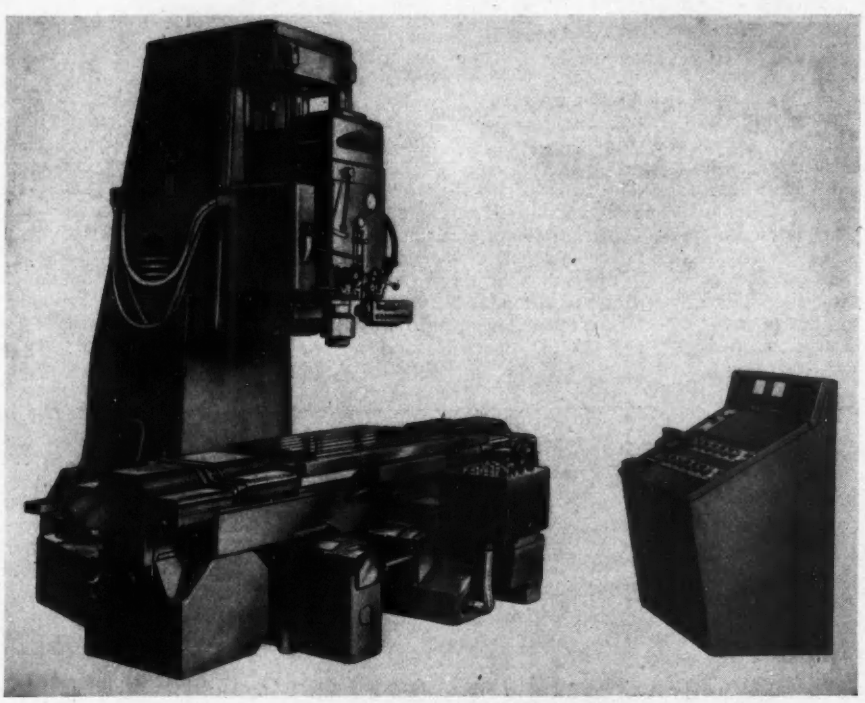


Fig. 37—"Spacematic 2657" jig boring machine with an automatic push button operated setting and control system—Newall

The table and the cross slide are carried on large anti-friction slideways and have hardened and ground main feed screws with anti-friction recirculating ball type nuts. Table and cross slide traverse power is supplied by a d.c. motor and two-speed gearboxes which are also used in connection with the automatic positioning equipment. This drive provides table and cross slide milling feeds from ½in to 12in per minute and a rapid traverse of 60in per minute.

The measuring and control system on the machine was specially designed in conjunction with The British Thomson-Houston Company, Ltd. Briefly the system consists of measuring bars in which are incorporated reference units accurately spaced at 1in intervals. These units are factory set to a high degree of accuracy and provision is made for trimming out any residual errors when they are fixed to the machine. An electro-magnetic detecting head is positioned by means of a remotely controlled micrometer to the required decimal proportion of 1in, and this senses the 1in reference units. The head is capable of detecting errors in position to an accuracy of 0·00002in and is entirely independent of fluctuations in electrical supply frequency or voltage. As no physical contact exists between the detector head and bar no wear can take place.

The required co-ordinates are selected by means of six dials for each motion. These dials serve to adjust remotely the micrometer screw and to select the whole inch part of the dimension, and they can be preset ready for the next co-ordinate while machining is being carried out at the previous setting.

Automatic positioning is initiated by push buttons which first unclamp the appropriate slide; give rapid traverse to within 0·2in of the final position (the direction of movement being determined automatically) and a slow approach to the final position, which is terminated by automatic clamping of the slide. Application of the clamps is indicated by lighting of a signal lamp and a further visual check is obtained by observation of an electrical coincidence meter on the control desk. Both slides may be set simultaneously. The final setting movement, amounting to approximately 0·02in, always takes place in the same direction. With the exception of this small movement, the slide always moves directly from one position to another without having to return to zero.

An important point about the control system is that, in the final stages of the approach to position, the speed of the positioning drive motor is controlled by a suitably amplified error signal generated by the detector head, the signal being gradually reduced as the head approaches zero position. In consequence, the positioning motor is automatically under close control right down to zero speed, and positioning is, therefore, entirely independent of limit switches, timers, automatic brakes, or similar apparatus.

The total setting time is the sum of the times due to distance to be moved (at the rate of 1in per second) and the final positioning of about six seconds. Thus a 4in movement takes about ten seconds or a 20in movement about twenty-six seconds.

As an alternative to dimension selection by manual rotation of the setting dials, these may be controlled by punched cards, one card being used for each pair of co-ordinates. Cards may be inserted into the machine individually, or fed automatically, there being no limit to the number of cards employed for production of any component. Dimensions selected by punched cards can be preset to save time and they are automatically shown on the dials used for manual selection.

The firm has also introduced a new model "O.P.2436" jig borer with an optical system for setting co-ordinates. This new machine (Fig. 38) has the same capacity as the standard "2436" machine fitted with the Newall system of table location by rollers and micrometers. It has a 24in by 36in capacity table and its feed box houses a 4½in diameter quill, the spindle speed range being from 40 to 2500 r.p.m., and having four feeds from 0·002in to 0·008in per revolution.

An optical projection system developed by Optical Measuring Tools, Ltd., which has been fitted for table location purposes, uses "U" shaped metal scales calibrated in 0·05in increments. Images of both scales are projected on to easily readable screens in a fixed console on the bed of the machine and give readings direct to 0·0001in. As 0·0001in of movement is represented by an 0·1in division on the screen, readings finer than 0·0001in are obtainable by interpolation and a repetitive accuracy of 0·000025in is stated to be obtainable.

Provision is made in the optical system

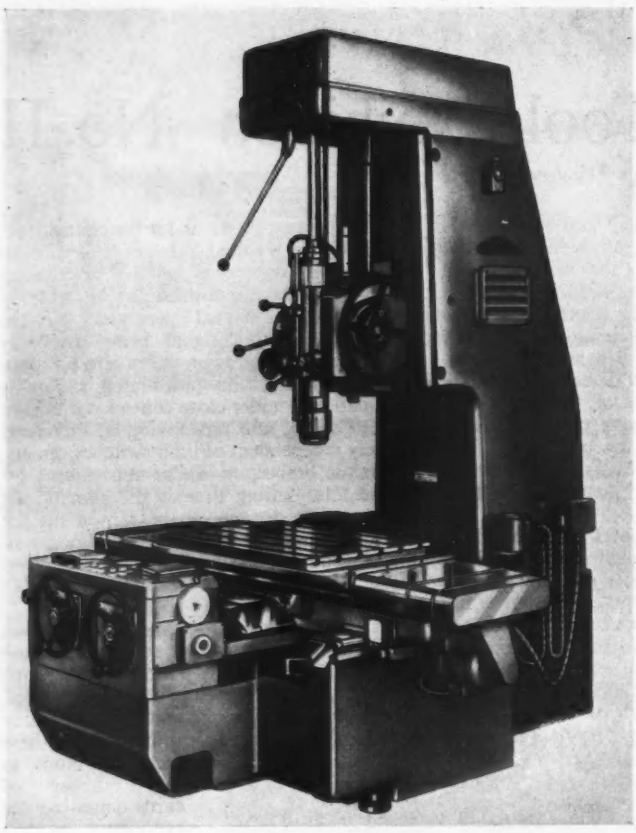


Fig. 38—Production jig boring machine with optical setting equipment —Newall

for presetting the coincidence graticule in readiness for a succeeding bore whilst the jig borer is in operation. With this optical system it is possible, having set to the workpiece datum, to set the system so that a complete zero reading of both inches and decimals appears on the screen, thereby making it unnecessary for the operator to add in certain fixed measurements to each reading, as usually applies. In addition, the scales may be set to read zero at any position in the range of travel of both table and cross slide; this considerably simplifies operation when it becomes necessary to set to a new datum on the workpiece.

The measuring system, entirely independent of lead screws and, therefore, in no way affected by mechanical wear, incorporates a compensating device by means of which correction can be made for dimensional changes due to slide wear after prolonged use. As an adjunct to the optical system, the mechanical scale indicates main 1in to 0·25in divisions to facilitate rapid setting.

The firm is also exhibiting a new fine boring machine which is available with either a single or dual spindle heads. It has a 20½in by 30¾in hydraulically-operated work table with a 15¾in by 30¾in working surface and a maximum traverse of 13in. Table feed rates from ½in to 16in per minute are steplessly variable through the hydraulic system. The controls are particularly simple, operation of a single lever causes rapid approach of the table and at a predetermined distance from the component a valve is actuated to reduce table movement to a feed rate applicable to the operation and material. On arrival at the dead stop the table reverses automatically to the loading position and the spindle is stopped by application of a dynamic brake.

An interesting group of the firm's well-known grinding machines includes the "3D" turbine blade grinder which has a fully automatic cycle and was described in our issue of December 3, 1954. This machine can be used for grinding the outside form and approximately 60 per cent of leading and trailing edge radii, together with platform and platform radius of non-ruled back blades. It has a capacity of 18in between centres and maximum swing of 8in. The design incorporates a wheel-head mounted, fully automatic form dresser, and compensation for reduction of wheel diameter after dressing. In addition to being used as a production machine, the grinder can be adapted to generate or regrind its own cams.

The automatic crankpin grinder exhibited (Fig. 39) incorporates an automatic mechanism for simultaneous removal of finished work and loading of unmachined crankshafts. It has a side, face, radii and periphery dresser which completes all phases of dressing in one passage of the diamonds across the wheel. This wheel-head mounted dresser is operated by push-button control, and has safety interlocks to prevent the truing cycle taking place unless the wheel is correctly positioned. The machine is equipped with air gauging equipment for control of pin diameters and has a cooling unit in the hydraulic system.

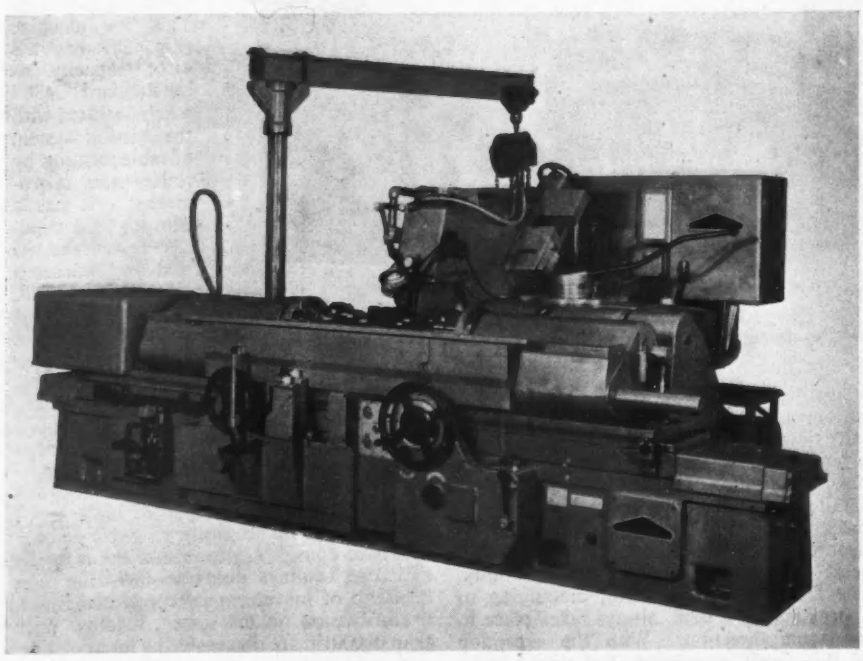


Fig. 39—Crankpin grinder fitted with wheel-head mounted dresser for completion of side, face, radii and periphery dressing in one passage—Newall

Adcock and Shipley, Ltd.

For a number of years the firm of Adcock and Shipley, Ltd., Ash Street, Leicester, has specialised in the manufacture of milling machines and special-purpose drilling machines, and we illustrate here two or three of this firm's machines which incorporate new developments. The "4HG" heavy duty horizontal miller, shown in Fig. 40, is based upon the "4AG" machine introduced in 1948, and is designed for rapid metal removal using positive, zero or negative rake tungsten-carbide cutters as well as high-speed cutters of conventional or high rake. Its table has a 72in by 17in working surface with a longitudinal traverse of 44in and a transverse traverse of 15in, the vertical adjustment being 19½in.

The machine is driven by a 25 h.p. motor and a spindle drive is so arranged that the diameter of the cutter in use is always less in diameter than the final drive gear. This, coupled with the use of a wide gear behind the spindle nose bearings, gives a flywheel effect as close as possible to the cutter to reduce torsional vibration to a minimum. A backlash eliminator incorporating a hardened table screw provides steady cutting conditions when climb milling is in progress.

Twenty-four spindle speeds from 23 to 1250 r.p.m. are available, and speed changing is effected by levers on the right-hand side of the column, the speed selected being very clearly indicated on a large dial. Feed changes are made from a knee mounting. Three feed ranges are changed by a knurled knob, which, used in conjunction with a handwheel, gives a stepless range of feeds from ½in to 64in per minute for longitudinal and cross movements and ⅛in to 16in per minute for the vertical feed. Rapid traverse which can be engaged from the front or the rear of the knee, is available at 150in per minute on the longitudinal and cross movements and at 37½in per minute to the vertical movement. A built-in speed and feed

calculator assists in selecting the most desirable speeds and feeds.

The knee on the new machine has been modified to increase the bearing surface for the cross slide, the width of the slide carrying the cross slide now being 24in. A modification to the lubrication arrangements gives automatic lubrication to all slides and traverse screws. Engagement of automatic feed to the table lubricates the table slideways and the table screw, and in the same way engagement of automatic feed to the cross slide lubricates the cross slide and the cross screw.

A straightforward design of vertical miller for toolroom and die sinking work is the "2 VSB" machine with a swivel head, shown in Fig. 41. It has a heavy rigid column within which is mounted a 3 h.p. four-speed motor and back gear giving eight spindle speeds from 40 to 1100 r.p.m. The head swivels on a large plate and is fitted with a vernier scale for accurate setting purposes. Vertical adjustment of this head with reference to a micrometer dial can be made through a handwheel-operated worm and worm wheel, and an adjustable micrometer depth stop is fitted.

The table has a working surface of 30in by 10in and a separate ⅓ h.p. motor driven gearbox gives nine longitudinal feed rates from ½in to 10in per minute. Cross traverse of the table is by hand and the knee has a vertical adjustment of 16in. A long knee is fitted to give a table cross traverse of 10in, and to ensure rigidity of this knee an additional support is provided at the front. With the knee down and the head up the distance between the spindle nose and the table surface is 18in.

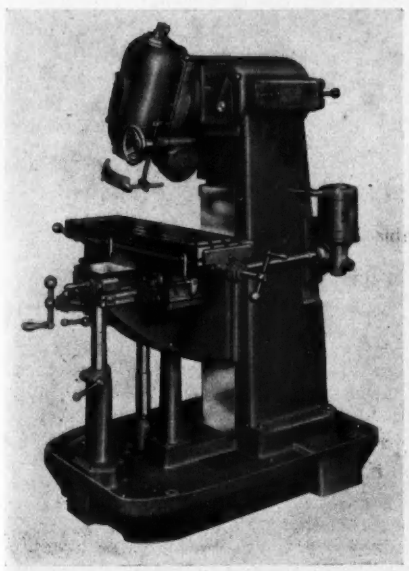


Fig. 41—Vertical tool-room milling machine with swivelling head incorporating means of vertical adjustment—Adcock and Shipley

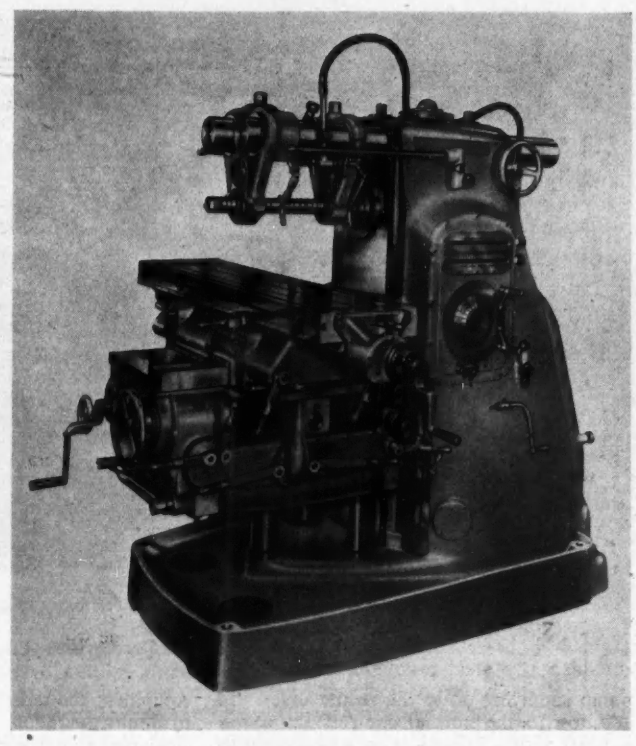


Fig. 40—Heavy duty horizontal milling machine with twenty-four spindle speeds from 23 to 125 r.p.m. and stepless feeds from ½ in to 64 f.p.m.—Adcock and Shipley

To provide a small milling machine with a fully automatic cycle the firm has developed a special cross slide for its "O" range of machines. These machines have a table with a 12in by 5in working surface, the respective traverses being 7in longitudinally, 4in transversely and 6in vertically.

The new cross slide (Fig. 42) has two cylinders built side by side on to it. One of these cylinders is supplied through a suitable valve with compressed air, and the other acts as a hydraulic dashpot. In the sequence of operations as the machine minder presses two handles the valve supplying air to the first cylinder is opened. This cylinder has its piston-rod attached to the table end bracket and it moves the table at high speed.

The piston-rod attached to the second hydraulic cylinder passes through the table end bracket and this piston-rod is fitted with adjustable lock nuts. These lock nuts are so adjusted that, just before the work reaches the cutter, the table end bracket meets the nuts, and at this point the air cylinder not only has to move the table, but also has to move the lock nuts, piston-rod and piston of the hydraulic cylinder.

The movement of the piston in the hydraulic cylinder forces oil from one end of the cylinder through a suitable metering valve to the other end of the cylinder. By adjusting the opening of this metering valve the rate of oil flow and thus the rate of table traverse is controlled. When the cutting stroke has been completed another trip mounted on the front of the table operates a further valve to change the pressure air feed to the opposite side of the air cylinder and thus return the table at rapid traverse rate to its original position where it stops.

This arrangement is offered on the firm's small horizontal and vertical machines, which can be equipped with any one of five speed ranges giving speeds as low as 150 r.p.m. or as high as 4000 r.p.m. In a prototype machine an additional cam was fitted to the table to operate a further air valve. This air valve controlled an air vice mounted on the table so that the cycle of the table operated the vice, thus making the operation of the machine completely automatic, the operator being merely called upon to load and unload. The components being handled were, it is stated, straddle milled in a floor-to-floor time of three and a half seconds.

An Adcock and Shipley twin-column, unit-head machine is shown tooled up with the necessary fixtures and multi-spindle drill head for core drilling, rough and finish drilling of Vauxhall steering shaft brackets. In this arrangement the head has nine spindles and the machine is fitted with a four-station indexing table, with cam-action damping for three components at each station. In each cycle of ninety-nine seconds three components are machined.

John Lang and Sons, Ltd.

The representative group of lathes to be seen on the stand of John Lang and Sons, Ltd., Johnstone, Renfrewshire, includes a 16in and a 20in model of the firm's new "B" range of lathes. The "10 B" model lathe, which we illustrate in Fig. 43, swings work up to 20½in over the bed and 13in over the saddle, and it can be supplied with eleven different lengths of bed from 10ft 6in to 30ft 6in to handle work from 60in to 300in long between centres.

Driving motors of 20 h.p., 25 h.p. or 30 h.p. can be fitted to these machines, and the twenty-four forward and reverse spindle speeds available with the respective motors range from 10 to 1005 r.p.m., 12·3 to 1235 r.p.m., and 14·6 to 1470 r.p.m. The main spindle which is bored 4in diameter, runs on three preloaded taper roller bearings. Spindle speeds are preselected on a dial on the headstock which faces the operator's position, and this dial is also marked with the cutting speed for any diameter of the work at the spindle speed selected. Operation of the speed change lever automatically stops and brakes the headstock gears, engages the preselected gears and then restarts the spindle. An interlock prevents the gears

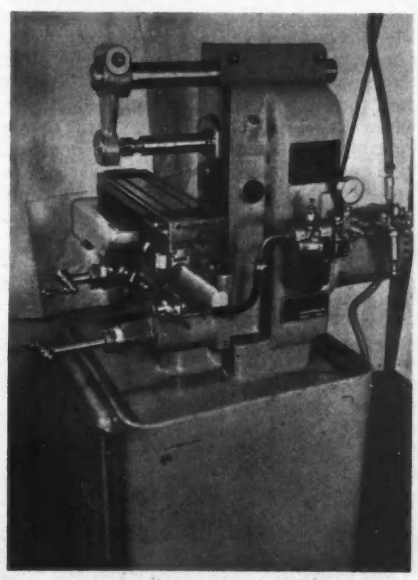


Fig. 42—Small horizontal milling machine with automatic table feed cycle actuated by a combination of pneumatic and hydraulic air cylinders—Adcock and Shipley

sliding until their shafts have been braked, and an idling drive is automatically engaged whilst the gears are sliding to assist their engagement.

Lubricating oil is fed to the headstock and gearbox from a sump in the bed of the machine and a magnetic cleaner is fitted in the system to remove metallic particles. The lubricating oil system is also used to operate the hydraulic forward and reverse clutches and the brake. The spindle nose is designed to take the maker's quick-release lock for chucks and drivers, and a spring-loaded centre can be fitted for end location of the work.

In the feed gearbox all changes are made by sliding gears on solid splined shafts, and through a direct-reading dial there can be selected all feeds : inch, metric, module and diametral pitches, and threads per inch. The change-wheel ratio is altered for metric, module and diametral pitches. The feeds, &c., are changed by the same lever as is used for the speeds by setting it in a different position in a gate. This feedbox incorporates similar interlocking and idling equipment to that used in the headstock for speed changing purposes. A lever on the gearbox is used to select the coarse or normal feed or thread ranges, and another lever is used to select whether feeds or right or left-hand threads are required. The sixty sliding feeds available vary from 9·5 to 1830 cuts per inch, and a similar number of surfacing feeds from 19 to 3660 cuts per inch.

The saddle is fitted with hardened strips in its underside faces which slide on the bed shears and the slides are pump lubricated from a sump in the apron. Its cross slide has a cross feed of 16½in and, if required, power feed for the tool slide can be fitted to some models of the lathe. With hand feed the tool post of the lathe illustrated has a travel of 5½in. The standard square indexing tool post has a toggle operated bind and location mechanism which requires only a light locking pressure. The locking lever also indexes the tool post which has eight positions at 45 deg.

All the gears and screwcutting half-nuts in the apron are lubricated by the same pump supplying oil to the saddle slides. In addition to the normal controls the apron is fitted with a joystick lever which controls quick power traverse for the saddle and the cross slide in both directions, power for the movements being supplied by a small motor on the saddle. An adjustable micrometer dial is fitted to indicate length of movement of the saddle along the bed.

If required, hydraulic profile turning equipment can be fitted on all models of the new lathe and one of the "10B" lathes fitted with this equipment is shown on the stand. On this lathe a profiling tool slide mounted at an angle of 45 deg. at the rear of the cross slide is operated by a hydraulic unit made by Hayes (Engineers), Ltd. This profiling slide is controlled by the tracing stylus through an 8in stroke hydraulic cylinder. When a lathe is fitted with profiling equipment the tailstock can be arranged for hydraulic operation. With this form of tailstock operation the speed and pressure of the feed can be controlled in drilling and boring work.

Another machine fitted with the "Unitrace" hydraulic profiling equipment is one of the firm's 17in swing sliding, surfacing and screwcutting lathes. This lathe is made in two sizes with 13in and 17in swing, and can be supplied in each size either as a sliding, surfacing and screwcutting machine or as a surfacing, boring and screwcutting machine for chucking work. In Fig. 44 the 17in machine can be seen as arranged for surfacing and boring. Twelve spindle speeds are available in three alternative ranges from 25 to 1105 r.p.m., 30 to 1289 r.p.m., or 34 to 1473 r.p.m. The saddle which carries a hexagon turret with a standard set of tool holders

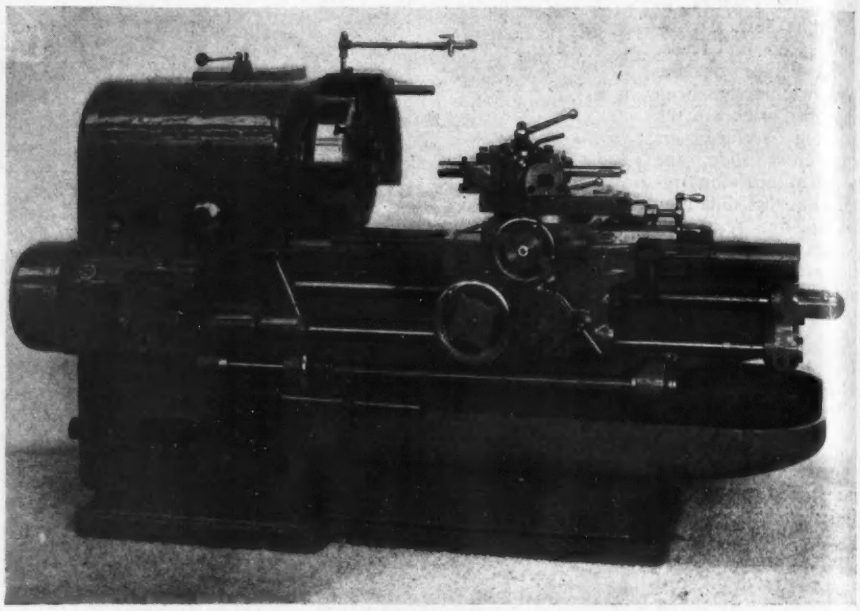


Fig. 44—17in swing surfacing and boring lathe—Lang

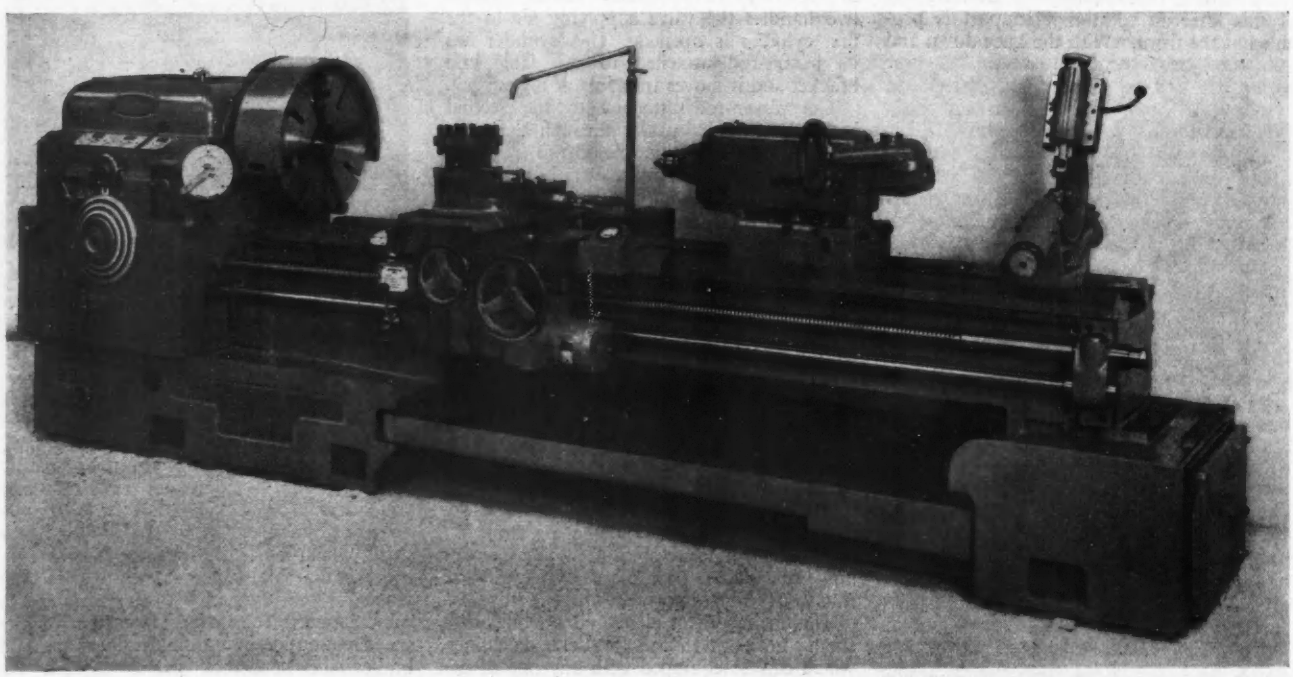


Fig. 43—20in sliding, surfacing and screw-cutting lathe with feed and speed preselection equipment—Lang

has twenty-eight feed rates through the gearbox. The sliding feeds range from 0·042in to 0·003in, and there are twenty-eight screwcutting feeds of from four to fifty-six threads per inch.

J. Parkinson and Son (Shipley), Ltd.

Three of the four universal milling machines exhibited by J. Parkinson and Son (Shipley), Ltd., Shipley, Yorks, are of conventional design and the fourth, which is illustrated in Fig. 45, is one of the firm's "Adapta" machines fitted with a swivelling cutter head. This cutter head is mounted on the ram carried on slide ways at the top of the column, and it can be swung through 90 deg. from the horizontal to the vertical position to present the cutter to the work at various angles. The ram slide has means of rack and pinion adjustment along the column to give the head 19in of movement over the table. This movement combined with the 10in cross traverse and 30in longitudinal feed of the table enables the cutter to cover a working area 29in wide by 30in long.

The spindle of the cutter head has an axial adjustment of 3in and it is driven through vee belts and gears by a 2 h.p. reversible motor, there being twelve cutting speeds through sliding gears from 43 to 1000 r.p.m. A separate 1 h.p. motor is used to feed the table, and the twelve rates of power feeds are from $^{9}/_{32}$in to 15in per minute longitudinally and transversely, and $\frac{1}{4}$in to 6$\frac{3}{4}$in per minute vertically. If required the cutter head can be fitted with a sub-head which can be operated in a plane at right angles to the cutter head or swivelled through 360 deg. around the cutter head axis. A slotting attachment which can also be fitted on the head has an adjustable stroke of 2in. When the machine is used for horizontal milling, as shown in the illustration, a 3$\frac{3}{4}$in overarm and arbor supports are used to provide a substantial outer bearing for the arbor.

This company is also showing examples of its well-known gear planers and gear testing equipment.

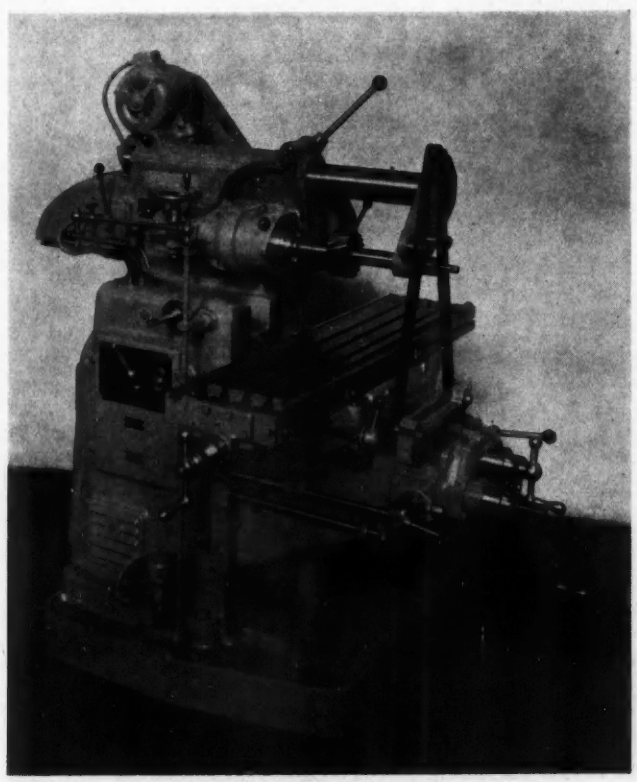


Fig. 45—"Adapta" milling machine with a swivelling cutter head arranged for horizontal milling. The cutter head can be swivelled through 90 deg. from the vertical—Parkinson

Shell-Mex and B.P., Ltd.

The cutting fluids, hydraulic oil, rust-preventing fluids and other lubricants and greases shown on the stand of Shell-Mex and B.P., Ltd., Shell-Mex House, Strand, London, W.C.2, include the range of "Tonna" oils which have been developed to overcome the "stick-slip" effect experienced on machine tool slideways. In connection with the development of these oils some special apparatus was designed at the Thornton Research Centre of Shell Research, Ltd., and one piece of this apparatus is shown on the stand. It is the measuring head for use on a modified Bardon friction machine, which was used as the basis of assessment of anti-friction properties in lubricants and the behaviour of the lubricants under conditions of typical loading and intermittent movement.

The head, shown in Fig. 46, consists of a base block on which there is guided a lower plate reciprocated by a hydraulic cylinder. An upper plate is maintained in frictional contact with the lower plate by a calibrated loading spring. A longitudinal spring coupled to the upper plate is designed to return it to its normal position if it is displaced by its frictional contact with the moving lower plate. The two plates represent slides, and the behaviour of the upper plate as the lower plate is moved indicates the relationship of static to kinetic friction induced by the lubricant under test.

When static friction is greater than kinetic friction the upper plate moves with the lower until the force of the restoring spring equals the static friction, and the upper plate slips relative to the lower. Since friction is now kinetic and less than the force exerted by the spring, the spring contracts and draws the upper plate back until it comes to rest once more at some position of lower force, whereupon the whole process repeats itself—an example, in fact, of "stick-slip" motion.

When kinetic friction is greater than static friction the upper plate again moves forward with the lower until the force of the spring equals the friction force and the upper plate slides on the lower, but no slip back occurs in this case while the lower plate continues to move. If the lower plate is stopped, however, the upper plate slips back until the spring tension is reduced to equal the static friction. The displacement of the upper plate (and hence the frictional force) can be measured by the use of a deflecting mirror and scale, and the coefficients of static and kinetic friction obtained with potential lubricants can readily be derived for conditions of speed and load typical of machine tool practice.

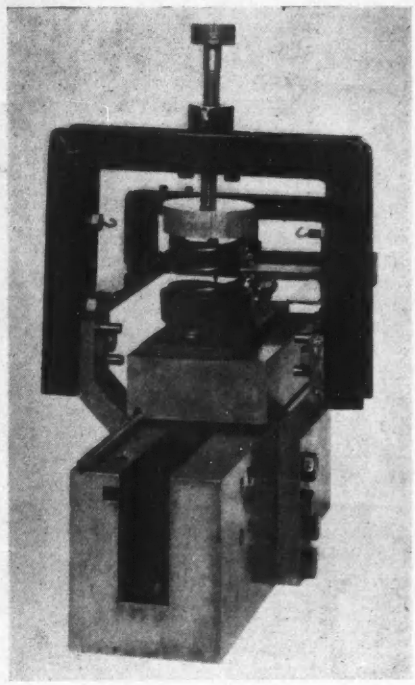


Fig. 46—Measuring head developed for assessing antifriction properties of lubricants—Shell-Mex

The "Tonna" oils developed to overcome "stop-slip" on slideways and bedways contain non-drip, anti-wear and oiliness additives and are made in various grades for particular applications.

W. E. Sykes, Ltd.

One of the new machines exhibited by W. E. Sykes, Ltd., Staines, Middlesex, is a high-production hobbing machine for gears up to 13in diameter by 4$\frac{1}{2}$in face width, and pitches up to and including 4 D.P. It has a capacity for producing spur gears and right and left-hand helical gears of any helix angle not exceeding 40 deg. as well as splines and serrations. An automatic hob shift mechanism can be set to act on completion of each component or for moving the hob after a predetermined number of parts have been machined. When the hob has moved the required distance a signal lamp is illuminated and depression of a return button returns the hob to its initial position. Alternatively, a change-over switch can be used to reverse the direction of hob movement. This machine, illustrated in Fig. 47, is built for an entirely automatic cycle which is started by depression of a push button after the component has been loaded. On completion of the machining operation rotation ceases, coolant flow is stopped, and the hob head and work spindle return to their original positions.

A new gear shaving machine, known as the "V.S.4A," shown in operation, shaves gears from $\frac{1}{4}$in up to 4in diameter with a maximum face width of 1in.

The coarsest pitch recommended for finishing with this machine is 16 D.P., and a gear mounted on, or integral with, a shaft up to 9in long, can be accommodated between centres. Where the gear is situated at the extreme end of the shaft, the total length should not exceed 6in.

The principle upon which this gear shaver (Fig. 48) works is rather similar to that used for transverse shaving, the work moving

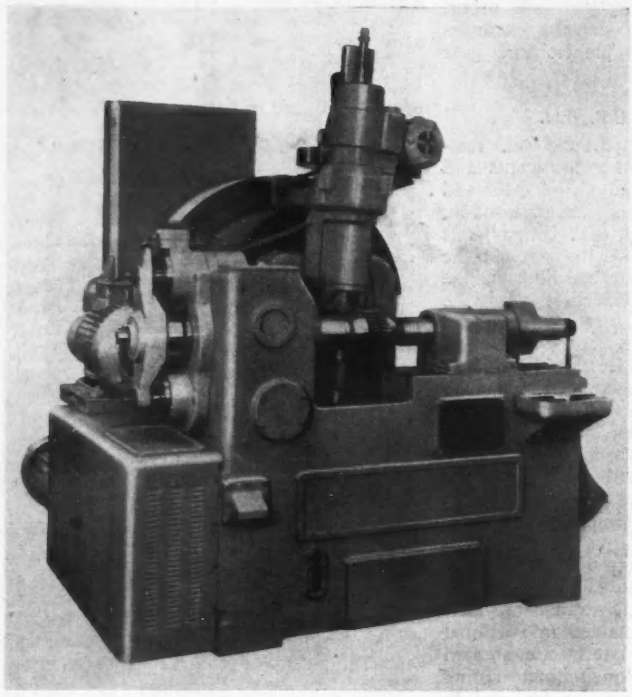


Fig. 47—High-production hobbing machine for spur and helical gears up to 13in diameter and 4¾in face width—Sykes

while the rotary shaving tool remains stationary ; also the tool is set to the required angle instead of the work. The finishing cycle is completed in four longitudinal strokes, the work and tool centre distance being progressively reduced after each stroke until the finished size is attained. A fast in-feed brings the shaving tool and work into the correct relationship before shaving commences, and the normal in-feed speed is engaged for the actual cutting operation.

Once the machine has been started the entire operating cycle is automatic, all that is required being the loading and unloading of components. An electrical cut-out switches the machine off when the cycle is completed.

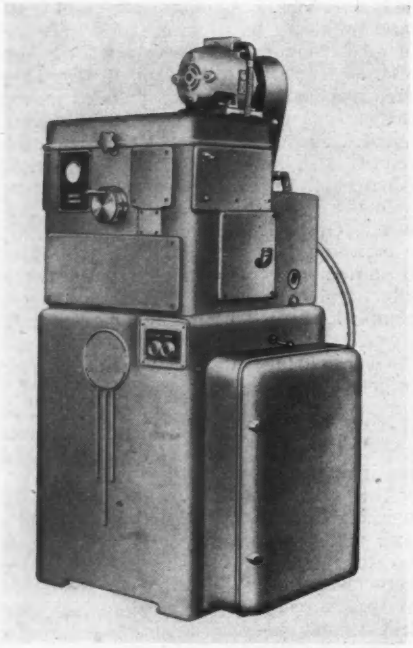


Fig. 48—Fine pitch shaving machine for gears up to 4in diameter and 1in face width—Sykes

Any of a range of six strokes and four feeds can be selected and rotation of the rotary tool can be continuous, or periodically reversed by operating a switch. At the maximum speed of 660 r.p.m., a maximum of ten reversals per minute can be obtained. At the minimum speed of 200 r.p.m. a minimum of three reversals per minute can be effected.

Representative of this firm's range of horizontal gear generating machines is a "3C" high production machine with a blank capacity of 40in diameter. On it there can be produced double helical gears with a face width up to 10in, spur gears from 2½ to 36 D.P., and helical gears from 3 to 36 D.P. The machine can be used for generating a variety of forms, including double helical gears with continuous or staggered teeth, external and internal spur gears, internal and external single helicals of either hand, irregular profiles, external and internal splines and serrations, and cluster gears with differing diameters and helices. A special feature of these machines is the facility for "ganging-up" cutters so that as many as sixteen components can be cut simultaneously. A typical set-up of four cutters generating a batch of eight components, each of ⅛in face, 18in P.C.D., 8/10 D.P., and 20 deg. pressure angle, will be displayed.

The "V.10A" vertical gear generator shown employs a single cutter spindle reciprocating in a vertical plane to produce a very wide range of regular and irregular profiles. An interesting point is the ability of this machine to generate racks, internal and external gears, spur and helical gears, involute and straight-sided splines and serrations. Internal gears up to 20in P.C.D. and 24in O.D., and external gears of 14in P.C.D. can be generated. The machine on view cuts cluster helical gears and uses a gapped cutter for roughing and finishing in a single operation.

Another gear shaving machine shown in operation is the "VS.8A," the smallest of three standard rotary gear shavers manufactured by the firm. On it spur and helical gears and splines can be shaved by the underpass, transverse or traverpass methods. This machine accommodates work of 8in maximum diameter (the largest machine in the range having a capacity of 18in), with a maximum face width of 5in.

As the work is located above the cutter on this class of machine, loading is considerably simplified as an uninterrupted view is obtained. Further, the shaving chips are thrown clear by the combined actions of centrifugal force and the cutting fluid. Thus, there is no tendency for the chips to wedge between the cutter and the component, and the working life of the cutter is considerably extended.

The machine has an automatic cycle, the operator's actions being limited to loading and unloading the work on the quick-acting headstock and starting the machine. When the cycle is complete, a warning light indicates that the next component should be loaded. At the exhibition the machine is shown shaving gears cut on the "V.10A" so that visitors may see the complete sequences of operations from the blank to the finished gear stage. Crowning attachments for the machine are also on view and in use.

Wadkin, Ltd.

The plant exhibited by Wadkin, Ltd., Green Lane Works, Leicester, includes a range of equipment to demonstrate the high-speed metal machining techniques which the firm has been developing in recent years. A universal miller, illustrated in Fig. 49, has been designed for milling operations on large components in non-ferrous and in ferrous metals, using interchangeable cap heads. It has four basic spindle speeds from 500 to

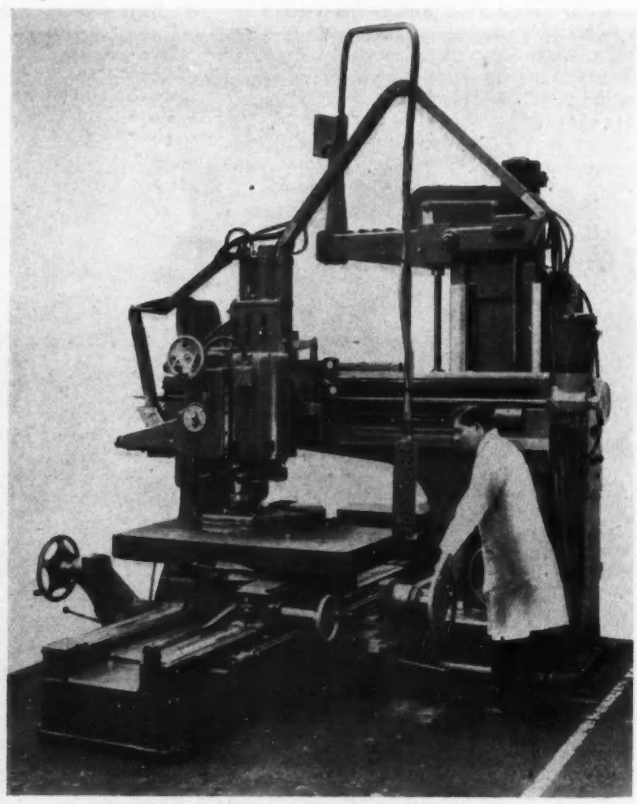


Fig. 49—High-speed universal milling machine for large ferrous and non-ferrous components. Its basic spindle speeds from 500 to 3000 r.p.m. can be reduced by interchangeable capheads to 30 to 180 r.p.m.—Wadkin

3000 r.p.m., which can be reduced by the addition of the cap heads to 30 to 180 r.p.m. or 165 to 1000 r.p.m.

The machine has a full range of power-operated movements to the spindle, including rise and fall, vertical down feed and cross traverse motions. The spindle can also be canted through 120 deg. The table, which has a working surface of 5ft by 3ft, accommodates a 3ft high component under the cutter spindle, and rotates through 360 deg. When this rotary table movement is employed work up to 5ft long by 5ft wide can be machined. A longitudinal power movement of table is infinitely variable from 1in to 100in per minute, and hand-operated motion by large handwheels is also provided.

A hydraulic copying equipment can be supplied, if required, to cover 6in vertical movement and also for controlling the movement of the cutter head across the table on the horizontal arm. Double rotary copying tables, when used in conjunction with the hydraulic contouring, enable the machining of round dies or opposite hand patterns.

This machine, whilst designed basically for accurate work on metal patterns in either cast iron or non-ferrous metal, can be used for operations on wood patterns. In machine shops it is suitable for a variety of face milling, profile milling, contouring for die sinking, and other purposes.

The new heavy duty high-speed router, shown in Fig. 50, is of the firm's overhead design with the routing machine mounted on a saddle on a long bed along which it is power traversed over a table fixed to the front of the bed and having a 12ft 8in long by 2ft 6in wide working surface. The cutting action of the machine is controlled with the aid of templates carried overhead on a structure supported by four pillars. By this arrangement attaching and detaching the templates to each individual component is avoided to give considerable savings in time. Where it is required to machine longer components without resetting, as in aircraft skin milling, provision is made for a second complete unit to be joined in tandem giving a capacity for the double machine 25ft long. The maximum width of a component is 5ft and its whole area can be machined in two operations by reversing and resetting the job on the table after one half has been routed.

The router head drive is by a 12½ h.p. motor at 18,000 r.p.m.; the head has two separate vertical movements, one controlled by graduated handwheel and the other by the operating handles. Accurate control of the depth of cutting is given by plunger-operated depth stops and a six-station capstan stop bar and dial indicator. The tracer pin is spring loaded in contact with the overhead template, and it is controlled by a three-position lever on the operating handle for easy movement of the two-step tracer for roughing and finishing, or complete withdrawal for working freely without template control.

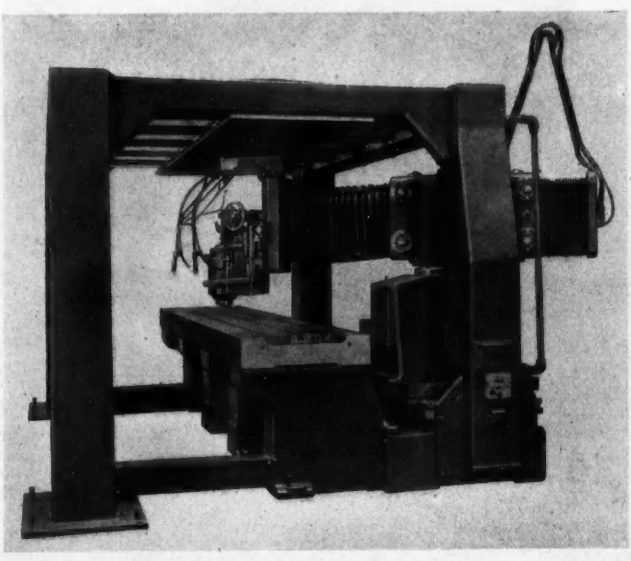


Fig. 50—Overhead template-controlled radial arm router with a 12ft long, 2ft 6in wide work table—Wadkin

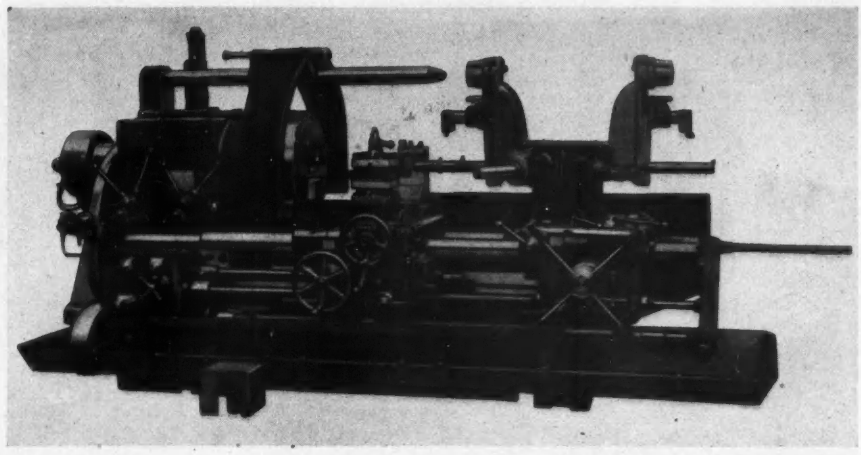


Fig. 51—Combination turret lathe with a swing of 30in over the bed and 21in over the cross slide—Herbert

Alfred Herbert, Ltd.

Representative types of the capstan, turret and copying lathes, milling, drilling and other machines of the firm's own manufacture are shown on the stands of Alfred Herbert, Ltd., Coventry, together with a range of the machines of British and foreign manufacture for which the company acts as selling agents. Much of the plant has already been described in our columns, but there are two new combination turret lathes exhibited. One, the 9C/30 machine, swings up to 30in over the bed, and the other, the 14/36, which swings up to 36in over the bed. The 90C/30 machine, illustrated in Fig. 51, is of powerful rigid design for heavy metal removal at high speeds. It is driven by a 25/7 h.p. two-speed motor and the sliding gear headstock provides thirty-two reversible spindle speeds from 7 to 600 r.p.m.

The direction of spindle rotation, starting, stopping and spindle inching, the quick-power traverse motor are all push-button controlled. Through dial and lever selection eight changes of reversible feeds from 20 to 480 cuts per inch, are provided for the sliding and surfacing motions of the saddle and longitudinal motion of the turret slide.

The firm's recently developed "Carbitracer" and the "Carbijunior" copy turning lathes are shown producing typical parts, and these machines were described in some detail in our issues of April 16, 1954, and February 3, 1956, respectively. Another new Herbert machine shown for the first time is a "No. 5 Senior" capstan lathe with a "Preoptive" headstock which takes bar work up to 2½in diameter or chuck work up to 16in swing. The headstock of this machine contains large multi-clutches capable of transmitting ample power to the spindle over a speed range of 21 to 5100 r.p.m.

The extensive range of measuring and inspecting equipment for which this firm acts as distributors is shown on a separate stand, and there is also a representative display of generally used small tools and machine shop accessories.

Drummond-Asquith (Sales), Ltd.

A number of the machine tools of German manufacture to be seen upon the stand of Drummond-Asquith (Sales), Ltd., King Edward House, New Street, Birmingham, have already been described in our columns. Amongst the largest of these machines is a Waldrich open-side hydraulic planer for work up to 59in wide by 47in high. Also to be seen is a "Pe Te We" projection form grinding machine in which the projected profile of the grinding wheel is guided by

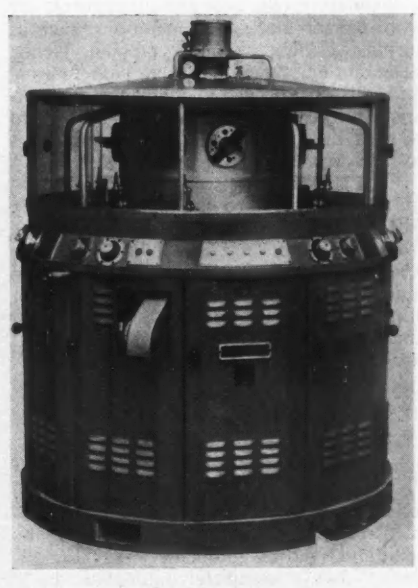


Fig. 52—Nassovia-Linstedt rotor ten-station chucking automatic—Drummond-Asquith

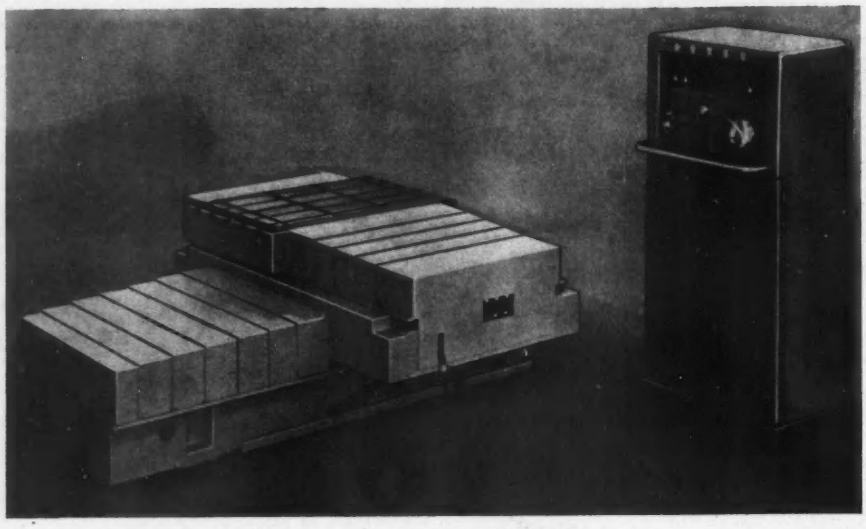


Fig. 53—" Jigmatic " compound table with digital positioning tape control equipment—Burton Griffiths

two large handwheels along a master drawing of the work at 10, 20, 50 or 100 times magnification. The operator sitting in front of the inclined projection screen can keep a close check on the workpiece and grinding head set immediately to the right of the screen.

A ten-station Nassovia-Linstedt chucking automatic, illustrated in Fig. 52, will be of interest to visitors who have not seen one of these production machines for small components. It consists essentially of an annular horizontal table on which there are nine vertical operating spindles equally spaced at 36 deg., leaving a gap at the front of the machine for loading and unloading. In the centre of the table is the turret or chuck carrier, around which are disposed the ten chucks in which the workpieces are clamped. This chuck carrier is indexed around its own vertical axis, and during the actual cutting time between indexing each chuck workpiece is held rigidly over the spindle whilst the machining operation takes place. Each chuck is capable of being indexed on its own horizontal axis whilst the turret is indexing, thus enabling different faces of the workpiece to be presented to the operating spindles.

Standard toolholders and attachments are available for machining operations, such as turning, drilling, reaming, tapping, facing, undercutting, thread chasing, both internal and external. Special attachments for multi-spindle drilling and tapping can be provided to meet the requirements of the component to be machined.

Each spindle has its own separate driving motor and combined hydraulic pump unit. The spindles are driven by chain and sprockets from their motors and have infinitely variable feeds which are set from a control knob immediately in front of each spindle. A fast approach and return motion is incorporated and this also is variable, according to the feed stroke required.

Burton Griffiths and Co., Ltd.

The machines of American and Continental manufacture shown by Burton Griffiths and Co., Ltd., Kitts Green, Birmingham, 33, include three Gisholt lathes—a " Masterline " turret lathe, a " Simplimatic " automatic and a vertical automatic. The " Simplimatic " has a completely automatic cycle and is intended for medium or long-run work. It consists essentially of a headstock, a bed and a platen table and swings work up to 33½in over the bedways and 21⅞in over the table.

The platen table serves as a mounting base on which a number of tool slides can be placed at various angles ; it carries the tools and slides to and from the work, and its traverse can be timed with slide operation to give tool relief, or to plunge cut or bore and eliminate need for complex slide arrangements. The table is moved by air cylinders under the control of a system of cams, stops and limit switches. Through change gears and back gears a selection of eighty spindle speeds, from 16 to 321 r.p.m., is available.

The Arter " Jigmatic " (Fig. 53) shown on the stand is a digital positioning tape control equipment designed to eliminate need for expensive tooling or jigging for the production of parts required in limited quantities. It can be used on the larger sizes of radial drills and consists of a 20in by 30in capacity work table mounted on a compound slide having two sets of ways set at right angles to each other. A tape reader housed in a separate cabinet controls movements of the table. The punched tape used for the equipment is prepared on a template design hand punch directly from the engineering drawings, and it is not necessary to code or convert this information in any way before punching the tape. All hole locations are referenced from *X* and *Y* co-ordinates, and it is only necessary that the workpiece is located on the table in proper relation to these axes. As many as 200 hole locations can be punched on one length of tape.

Two electric motors drive the table through a system of gears and clutches, and it is positioned by two precision ground lead screws. The drive and control mechanism incorporates an automatic mechanism to provide final positioning in only one direction regardless of the original direction of table travel. When in position the slides are securely locked by an electro-magnetic brake.

A Blanchard " 18C " vertical spindle surface grinder exhibited is a new machine designed for either automatic cycle or manual operation and it handles work up to 36in diameter by 12in high. A Blohm horizontal spindle surface grinder for toolroom or production work handles work up to 39in long by 9⅝in wide. It has an automatic, electrically-operated cross-feed which is infinitely variable up to 2½in per table stroke. The infeed equipment with its vernier scales and accurate lead screws, allows a cross feed of 0·004in and a depth feed of 0·00004in by a single action of an inching button. An automatic, electrically controlled, depth feed permits an infeed of 40–50 micro-inches and gives automatic operation as the infeed is disengaged upon reaching the preset depth limit. This depth feed and the cross-feed control equipment enables automatic grinding on the machines.

A group of the well-known Maag gear cutting and grinding machines can be seen on this stand, together with one of the firm's

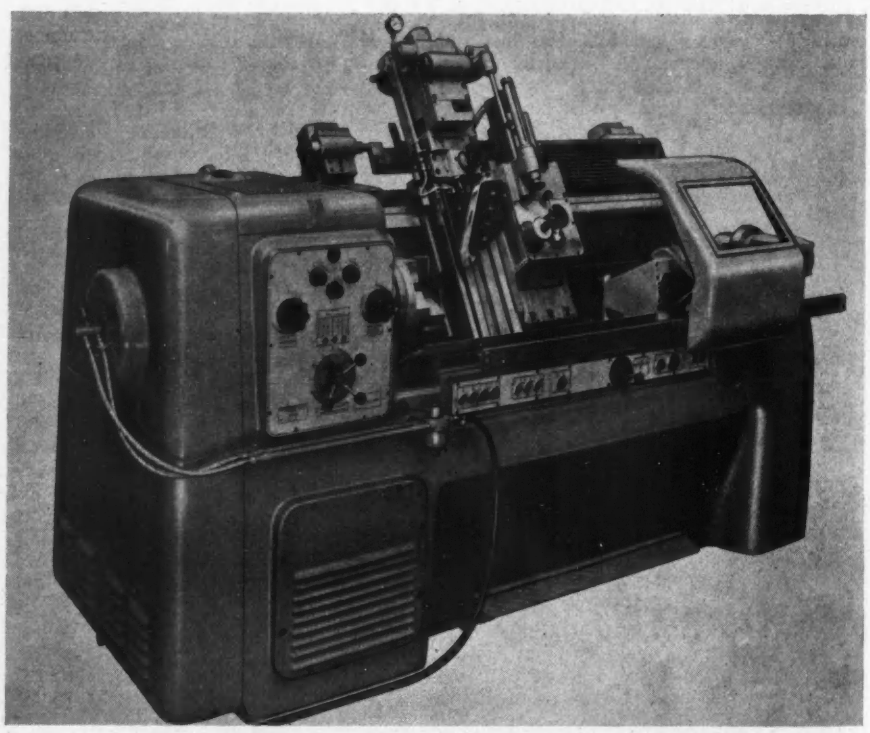


Fig. 54—Heyligenstaedt " Heycomat " copy turning machine with multi-cut equipment—Burton Griffiths

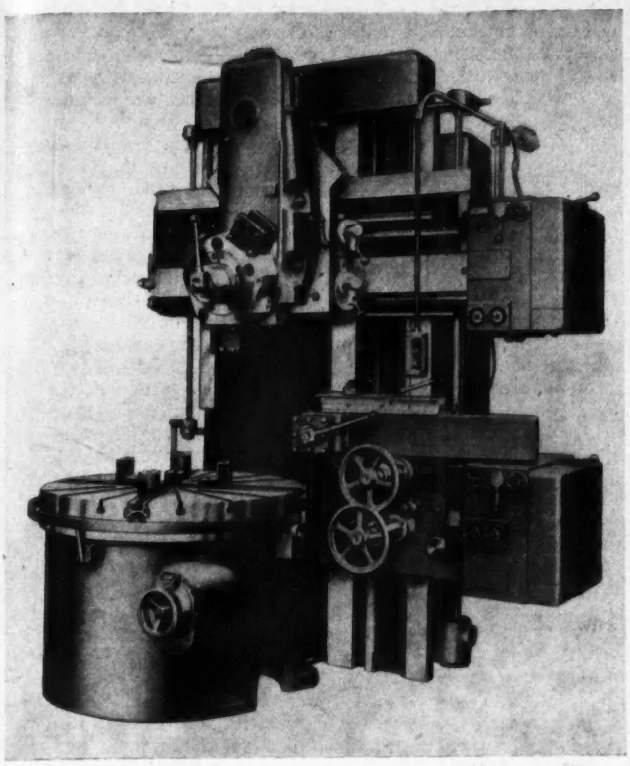


Fig. 55—Schiess vertical, 49in capacity boring mill—Burton Griffiths

tooth profile and helix angle checking instruments. The "SH75C" machine in this group, which is designed for the cutting of spur or helical gears up to 29½in diameter, was illustrated in one of our Plates last week.

The Heyligenstaedt copy turning machine illustrated in Fig. 54, turns work up to 16½in diameter over the bed, and 7in over the slide; and is made with four bed lengths to accommodate work 20in, 30in, 40in and 60in long. On this machine the main drive is from a 25 h.p. motor through vee belts to a three-step gear control gearbox with electromagnetic clutches. A six-step sliding gear is connected to the three-step gear, which is controlled automatically in ratios of 1·6 : 1, 1 : 1 and 1 : 1·6. The gear control is governed by the position of the copying slide, and the changing points can be determined anywhere over the work turning range to give a constant uniform cutting speed. Altogether, there are fifteen main spindle speeds, ranging from 71 to 1800 r.p.m.

The feed mechanism consists of P.I.V. gear, driven directly from the main spindle by spur gears. With the use of three push buttons arranged on the apron control panel, it is possible to select three different steplessly variable feeds in the range of 0·004in to 0·031in per revolution. The feeds are automatically engaged at pre-selected points while the work cycle is in progress as often as required, and it is possible to regulate the feeds while cutting.

The hydraulic copying device is mounted on the carriage and operates on the "Heyco" single-edge control system; the copying range with increasing shoulders being up to 90 deg., and with dropping shoulders up to 30 deg. The machine is normally equipped with a two-cut automatic attachment which enables machining with copying cut or with roughing cut and a finishing cut. If required, it can be fitted with a six-cut automatic attachment for cases where a considerable amount of stock has to be removed. When this six-cut automatic equipment is used the auxiliary tracer on the copying slide runs against a stop on the stop drum. Four stops can be arranged on the drum circumference, according to the depth of cuts required, and these cuts are followed either by a copying cut or by a copying roughing cut and copying finishing cut.

A special purpose Huller machine demonstrated machining a cast iron component, consists of a number of unit heads assembled on a common base. One of the units is an angular milling head and hydraulic cutter lifting mechanism, in which the drive for the milling spindle is provided by a built-in electric motor via a layshaft. This unit is mounted on a table which gives rapid movement in both directions in addition to working feed, under the control of an infinitely variable feed pump.

A hydraulic boring slide on the machine has a combined multi-spindle head consisting of six drilling spindles and a facing spindle with quill. Spindle drive is by an electric motor and gearing. The unit, which is counter-balanced by a weight, is mounted on a column and its movements are hydraulically operated, the length of stroke being adjustable. The tools of the drilling spindles are guided by a tool steady and the depth can be set by adjustable spindle sleeves. The slide, with the machine column, is fixed to a side frame which incorporates the hydraulics equipment, including a two-stage pump, oil container, oil filter, pressure gauges and valves.

The whole unit head assembly is flanged on to the main base, which carries a hydraulic indexing table of 30in diameter with ten indexing positions. Enclosed in the main base is the indexing, locating and clamping mechanisms and coolant pump and tank. The table is surrounded by a chip pan from which an opening allows the swarf to slide into a swarf container.

Two Schiess machines are shown—a large horizontal milling and boring machine and a high-speed vertical boring mill. The vertical boring mill, a photograph of which is reproduced in Fig. 55, has a maximum turning capacity of 49in diameter, and its table takes work weighing up to 4 tons. This machine has sixteen table speeds, from 4·7 r.p.m. to 237 r.p.m., and two ranges of twelve feeds, giving from 0·0023in to 0·262in per revolution in each direction. Its tools are held in the five-station turret in split bushes set below the surface so that large tools or holders can be flange mounted on the face.

The side head, which incorporates a four-way tool post, is carried in long, narrow guides on the column. Power quick-traverse is provided and the side head feeds can be set independently of those for the cross rail head. Electromagnetic clutches are fitted in the feed box and enable the fitting of an electric copying attachment when specified.

Rockwell Machine Tool Company, Ltd.

Some fifty machines of British, American and Continental manufacture are being shown by the Rockwell Machine Tool Company, Ltd., Edgware Road, London, N.W.2, and of these machines nearly a half are being exhibited in this country for the first time. Two of the largest machines, a "460-FUAR" 6in spindle, and a "350-T," 5in spindle horizontal boring, drilling and milling machines, made by Giddings and Lewis Machine Tool Company of America, are of particular interest. As in the case of some of the other American machines on this stand, they were both described in some detail in our articles on the Chicago Machine Tool Exhibition last year, but a few points of their design are worth noting. All spindle movements on the 6in "460-FVAR" machine are push-button controlled, the speeds and feeds being selected by means of dials on the main control panel. An underarm support for the spindle can also be used to carry offset and angle milling attachments, or shaping and slotting attachments.

The "350-T" machine is equipped with a B.T.H. three-dimensional tracing unit and has a 36in spindle travel under full tracer control. This control system gives simultaneous automatic control of the saddle and headstock, or saddle and table, for die milling work. Alternatively, the table and headstock may be automatically controlled for profiling work. A single tracing head, sensitive to

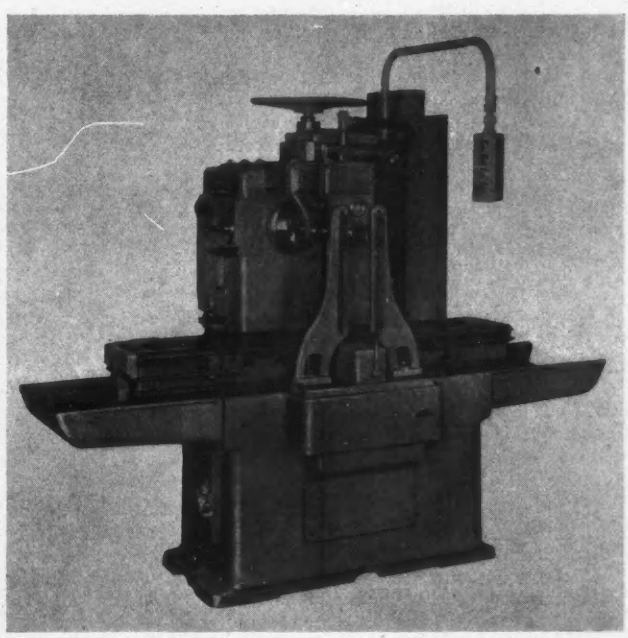


Fig. 56—Sundstrand "Rigidmil" production milling machine—Rockwell

Fig. 57—Werner heavy-duty vertical milling machine fitted with preselection equipment for feeds and speeds—Rockwell

deflections in three dimensions, is used for copying work, the three feed motions being driven by independent d.c. motors, each of which is powered by its own d.c. generator on the Ward-Leonard principle. These generators are regulated by an electronic control which responds to signals developed in variable inductance coils in the tracing head. The individual feed rates are varied by adjusting the speeds of the d.c. motors. In die milling operations, the stepless feed of the tool over the surface of the work remains constant, irrespective of the steepness of the contour, and adjustable limit switches automatically reverse the feed at the completion of each pass, simultaneously setting the next cut. The feed rate in low gear can be varied from 0·4in to 5in per minute and in high gear from 4in to 40in per minute. The rate of feed can be altered during cutting and a rapid power traverse of 120in per minute operates for all three feed motions.

A model 22 " Rigidmil " exhibited (Fig. 56) is manufactured in Germany under licence to the Sundstrand Machine Tool Company, of Rockford, Illinois. This bed type production milling machine has eleven work cycles which can be selected by the setting of a few table dogs. A mechanical feed box with 100 to 1 ratio between high and low feed rate is fitted, the table being driven by a fixed screw and rotating nut. The feed changes are effected by pick-off gears used with two different driving gear shafts, which greatly increases the range between high and low feed rates and enables four different feeds to be obtained with each set of two feed-change pick-off gears. Similarly, the workhead, which gives a spindle speed ratio of 80 to 1, also has two driving gears enabling four speed changes to be made with one pair of gears. The spindle speed range is from 20 to 1600 r.p.m. A backlash eliminator is fitted as standard equipment and the machine is equally suitable for conventional and climb milling.

One of the two lathes of the Monarch Machine Tool Company, Ltd., of America, which are exhibited is a 21in "Mona-Matic" with constant cutting speed equipment. It has an automatic "four-cut" work cycle by which a multi-cut device provides four completely automatic passes of the tool over the workpiece. The first two cuts are roughing passes, controlled by an air-actuated indexing stop unit, working in conjunction with an air gauge tracer stylus. The third cut is a semi-finish pass controlled by a template and the fourth and finish pass, also template control led, is performed when the template holder automatically indexes to bring the finished profile template into operation. A multi-cycle programmer fitted to this machine consists of a cam drum having up to twenty-four control cams. The drum is arranged so that it indexes one-twentieth of a revolution at a time, and its cams control a series of switches controlling feeds, length of cut, and operation of rear slide. Power for the front carriage feed and rapid traverse is supplied by an electronically controlled motor housed in the gearbox compartment. The final drive to the feed shaft is through precision gears, and the shifting of gears is carried out by hydraulically operated clutches. The constant cutting speed headstock of this machine enables correct cutting speed for a given material to be used, irrespective of the diameter to be turned. The constant surface cutting speed mechanism provides a 4 to 1 ratio and is powered by a 25 h.p. variable-speed drive controlled by a rotary converter and electronic equipment.

A jig boring machine built by Abawerke G.m.b.H., of Germany, has a work table area of 16in by 26in and a spindle travel of 8$\frac{3}{4}$in. Its boring head is counterbalanced by weights inside the column and encloses the two-speed motor of the main drive and a six-speed gearbox giving a range of spindle speeds from 37 to 1800 r.p.m. The table and cross slides are operated by precision lead screws with fine adjustment. A Leitz optical measuring system consists of two hair-line microscopes and precision lenses scanning measuring scales and a setting accuracy of 0·0002in is claimed for the machine, the microscopes reading to 0·00005in. A precision surface grinding machine of this firm is fitted with variable-speed drive giving a range of wheel speeds from 400 to 4000 r.p.m. This variable-speed drive enables the operator to choose the precise surface cutting speed to suit any given class of work and size of wheel.

A number of milling machines made by Fritz Werner A.G. are shown on the stand and one of particular interest is the heavy duty " Model 5235 " vertical machine, illustrated in Fig. 57, which has a 90$\frac{1}{2}$in by 19$\frac{5}{8}$in table. This machine is driven by a 40 h.p. motor enclosed within the column and driving through a clutch and back gear. The gearbox through which the spindle is driven is controlled by a preselector and an electro-hydraulic unit. It gives forty-two spindle speeds from 16 to 1800 r.p.m., and new speed rates can be selected with reference to an indicator whilst the machine is cutting. The change in speed is effected when required by depression of a push button, and whilst the gears are being rearranged for the new speed they are rotated slowly by a separate drive.

The milling spindle is mounted in a substantial quill and is driven through spiral gears, the final drive gear being carried in a separate bearing in the spindle head housing to prevent any gear pressure being transmitted on to the spindle. The spindle quill can be traversed longitudinally by a handwheel and a four-stage turret stop with a dial indicator facilitates repeat settings. The milling head itself can be swivelled through 45 deg. on each side of its vertical position.

The table of the machine is supported on long guides and table feeds are transmitted through a vertical shaft, driven by the main

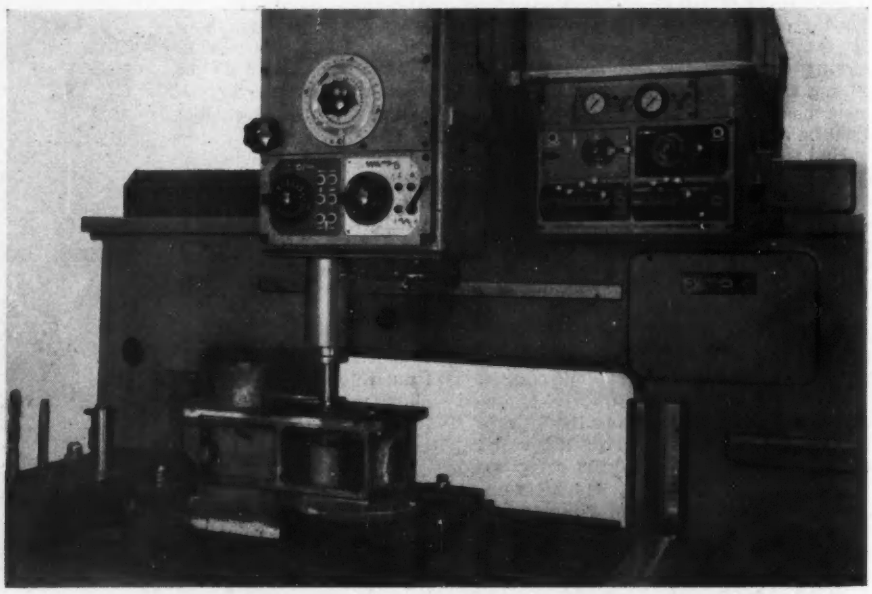


Fig. 58—"Bemag" co-ordinate boring and milling machine with automatic precision spindle positioning—Rockwell

back gear, a feed box, and finally through a large worm which engages a milled worm rack. The knee is particularly rigid and carries the cross slide on wide ways. Hydraulic clamping is provided for the longitudinal slide, the cross slide and the knee and automatically comes into effect on the slides not in operation once the direction of feed has been selected.

The feed gearbox is of cylindrical design and is fitted as a complete unit into a housing in the knee. The appropriate gears are engaged by electromagnetic clutches and the required feeds can be preselected whilst the machine is running on an indicator-selector unit at the front of the knee. It gives fifty feed rates, from ¼in to 79in per minute longitudinally and transversely, and ¼in to 39½in per minute vertically. Rapid power traverse rates are 200in per minute longitudinally, 120in per minute vertically, and 60in per minute under hand control, longitudinally and transversely. A single control lever is used for starting, stopping, braking of the spindle, disengagement of table feed and automatic traverse.

An indicator panel on the left-hand side of the column facing the operator shows the speed and direction of rotation of the spindle, and the rate and direction of feed and knee position. When using the machine on production work, a rise and fall mechanism fitted to the machine can be engaged to lower the knee automatically some 2in when the feed is disengaged after a cut, and re-elevate the table to its initial position after it has been returned to its start position.

A boring machine made by Berliner-Maschinenbau-Aktien-Gesellschaft, of Berlin, incorporates preselection of co-ordinate settings, spindle speeds and feeds. This machine, as can be seen in Fig. 58, has a bridge design column on which there is mounted a longitudinal slide which carries the cross slide with the spindle head. Each slide is a self-contained unit complete with precision setting equipment. These setting equipments each consist of a line of drums or magazines, each of which carries a number of precision end measuring rods. An electrically-operated preselector is used to align the rods required for the length of the linear setting of the appropriate slide, and on depression of a button the slides are moved hydraulically to the settings. The ranges of end measuring rods are designed to permit slide adjustments in increments of 0·0002in.

With this setting equipment and the design of the machine, drilling, boring and milling operations can be carried out without the need for marking out, or use of jigs. The longitudinal spindle traverse is 50in and the cross spindle traverse 30in, whilst the table has a working area of 38in by 58in, and the maximum distance between the spindle and the table is 31in. Vertical adjustment of the table is provided by four ground screws driven by planetary gearing and fitted with backlash eliminators. Table height adjustments are push-button controlled and the table is clamped automatically on releasing the button. Both the longitudinal and cross slides are hydraulically clamped when in their working position.

Co-ordinate settings are made by moving two groups of counter drums fitted to the front of the machine by the spindle head. Each group of drums contains six figures, the last drum reading 0·0001in, going up in steps of 0·00002in; all other drum digits advance in steps of one. Thus, the machine can be set, for instance, to 29·4624 or 29·4626. Preselection of the co-ordinates for the next hole to be drilled or bored can be made whilst the machine is still working on the first hole. As soon as the spindle has been retracted from the first hole, it only needs two buttons to be pushed and the machine automatically rearranges itself to the previously selected co-ordinates. This machine is provided with eighteen spindle speeds, from 35 to 1800 r.p.m., and nine boring feeds, in addition to steplessly variable milling feeds. The spindle is driven by a 5½ h.p. motor.

George Swift and Sons, Ltd.

One of the four lathes on the stand of George Swift and Sons, Ltd., Halifax, is a 21in centre machine on a 25ft 6in bed to admit work up to 16ft between centres. It swings work up to 42in diameter over the bed and 29in diameter over the saddle. This machine, shown in Fig. 59, has twenty-seven spindle speeds ranging from 1·7 to 230 r.p.m., the nine lower speeds being obtained through a faceplate gear and the remaining eighteen with the faceplate pinion withdrawn. It has the usual sliding, surfacing and screwcutting motions and feed to the top slide for angular turning or boring purposes. A nine-speed feed box gives feeds ranging from 10 to 600 cuts per inch. A quick-power traverse is fitted for both the sliding and the surfacing motions. The machine is driven by a 30 h.p. motor and the headstock is fitted with an ammeter and a tachometer to show the current consumption and the spindle speed.

A "T" lathe on this stand takes work up to 20in diameter and is fitted with hydraulic copying equipment. The spindle has twelve speeds from 14 to 500 r.p.m., and a constant cutting arrangement can be used to increase spindle speeds as the tool is fed in towards the centre. A reversible driving motor is fitted so that the tool can cut either at the front or the rear of the centre, and a quick-power traverse in each direction is fitted to the surface motion.

A "12 SV 6" lathe exhibited swings work up to 24in diameter and its four-way tool turret is mounted on hydraulic copying slides, which provides copy forming motion to the surfacing slide.

Optical Measuring Tools, Ltd.

The precision optical measuring and inspection equipment of Optical Measuring Tools, Ltd., Maidenhead, includes the large capacity workshop projector. It has a 60in by 40in viewing screen, gives magnifications from 5 to 100 times, and the workpieces can be finished directly on the mounting whilst imaged on the screen.

On this projector the optical path from the light source past the workpiece and through the projection lens, is parallel to the screen. This enables the toolmaker to stand close to the screen and at the same time have all controls in accessible positions. The optical system is so arranged that the image on the screen is in correct relationship to the workpiece and not inverted.

Among the selection of lenses available, is an 18in gauge projection lens covering a 6in field at 10 magnifications, and with it a large profile can be finished and checked at one setting. Lenses are easily mounted on the carriage on the table of the projector with the exception of 18in and 29in lenses, which are both permanently mounted, but are retractable from the light path when it is required to change the magnification.

Near the focal plane of the projection lens is mounted a workholder having vertical and lateral movements and when work is brought into focus it is known that the magnification is correct. In the case of templates for dies and similar work, it may be necessary to vary the magnification slightly

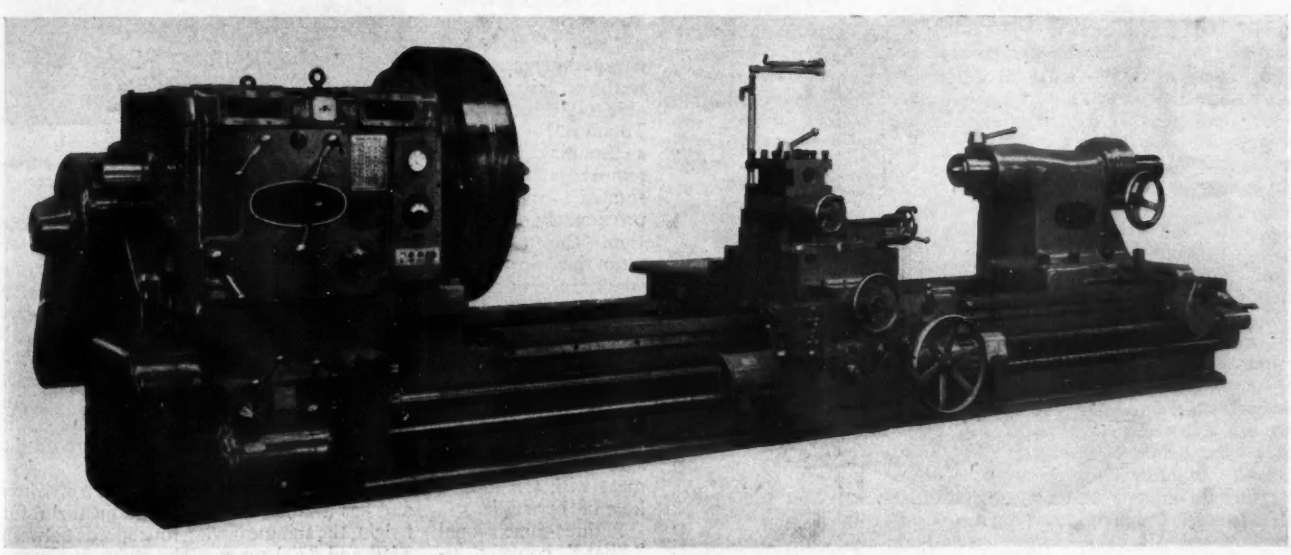


Fig. 59—21in centre lathe with a 25ft 6in bed. Twenty-seven spindle speeds from 1·7 to 230 r.p.m. are available and feeds from 10 to 600 cuts per inch—Swift

to allow for a known contraction or expansion. This may be achieved by moving the large rear mirror backwards or forwards, thereby lengthening or shortening the optical path and varying the magnification. A handwheel control is provided for this operation, together with a locking device and scales indicating the amount by which the magnification is adjusted.

Enlarged drawings of profiles to be checked may be attached to the 60in by 40in screen, which is also fitted with vertical straight edges and locators for positioning a further straight edge horizontally or angularly. If it is wished to check the magnification at any time, special graticules are available which are merely inserted into the workholder and their images measured.

Also shown on this stand are the firm's standard and "Model E" projection pantometers, for rapid and accurate inspection of three-dimensional contours such as turbine blades. The "Model E" instrument, with a 24in by 12in viewing screen has been specially developed for experimental and similar work requiring frequent changes of blade profile.

E. H. Jones (Machine Tools), Ltd.

A number of machines of American design now being built in this country by C.V.A., Ltd., are to be seen on the stand of E. H. Jones (Machine Tools), Ltd., Garantools House, Portland Road, Hove, 3, Sussex. A 16in model "Powerturn" tool-room lathe, which swings 20½in over the bed, is made in a number of sizes and with centre distances from 54in to 126in. This machine (Fig. 61) has a headstock of new design with a range of twenty-four spindle speeds up to 2000 r.p.m. A built-in computing mechanism is designed to speed speed selection and with it the required work speed is calculated by setting two dials and indicated by selection lights keyed to the three speed setting levers.

A quick-change gearbox gives fifty-five feeds from 0·0007in to 0·047in per revolution of the spindle, and a thread cutting range from four to 256 threads per inch. By transposing two gears this feed range can be arranged to cover fifty-five further steps, giving from 0·0029in to 0·187in per revolution of the spindle, and one to sixty-four threads per inch when screw cutting. The carriage has replaceable hardened and ground steel cross slide ways, and the cross feed and top slide dials read directly in diameter increments of 0·001in.

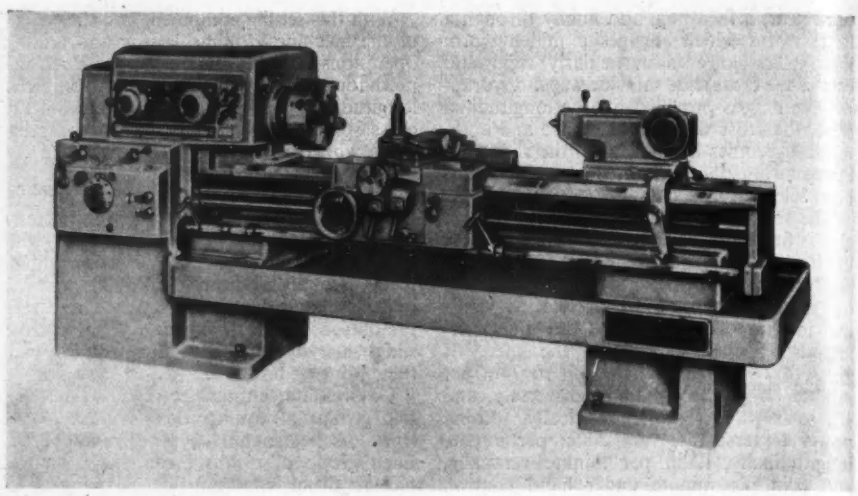


Fig. 61—16in "Powerturn" tool-room lathe with a spindle speed computing and indicating mechanism in the headstock—Jones

Kearney and Trecker milling machines in the "TF" series are also being made by C.V.A. and one of the "415" model horizontal machines exhibited is illustrated in Fig. 60. This machine has a table with an 80in by 15½in working surface, with a movement range of 42in longitudinally, 14in transversely, and 18in vertically. It has a 15 h.p. main motor which, through the gearbox, gives twenty-four spindle speeds from 15 to 1500 r.p.m. A 3 h.p. motor is fitted for the feed drive gearbox, which gives thirty-two feed rates from ½in to 90in per minute longitudinally and transversely and from ¼in to 30in per minute vertically.

The machine is particularly intended for heavy duty work and twin elevating screws, coupled together by gearing to act in unison, are fitted to provide adequate support to the knee. A new method of adjusting the backlash eliminator on these machines consists of an external lever and worm shaft which controls the adjustable table screw nut. This lever is mounted on the serrated outer end of the worm shaft and is secured to the front of the saddle with a retaining screw. The worm on the inner end of the shaft engages integral worm teeth on the adjustable table screw nut. To adjust for backlash a retaining screw is removed and the lever rotated clockwise approximately one serration. This action rotates the worm shaft, which in turn rotates the adjustable nut to take up a given amount of backlash. The lever is then removed from the serrated end of the shaft and reinstalled so that the retaining screw hole is in alignment with the tapped hole in the saddle.

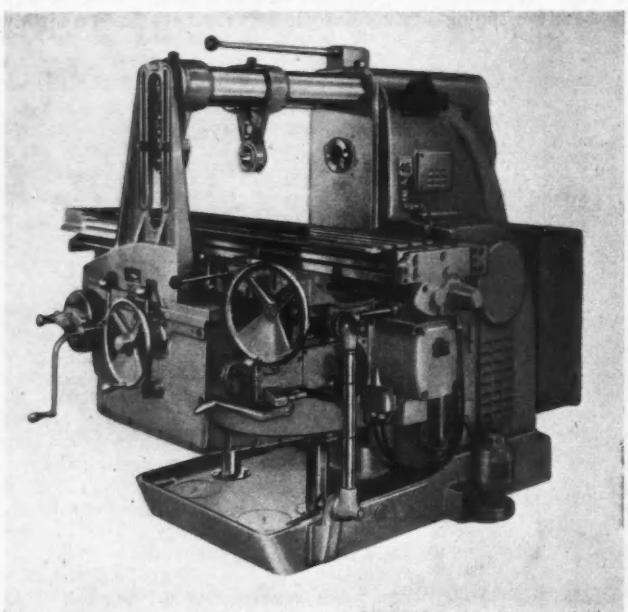


Fig. 60—Horizontal model "415-K & T" heavy-duty milling machine—Jones

A three-dimensional "Silex" copying attachment exhibited has a working ratio of 1 to 1 and is designed for mounting on the overarm of a horizontal milling machine, as shown in Fig. 62. By using the combined vertical and cross traverse movements of the attachment and the longitudinal movement of the machine table irregularly shaped workpieces can be reproduced by copying. In this attachment the motor-driven cutter spindle and the stylus head are mounted on a transverse slide, which is moved laterally by a light hand lever. A similar slide on the opposite side of the attachment is coupled to move in the opposite direction, and by transferring the stylus head to that side reverse copying can be performed. The transverse sides are mounted on a vertical slide which through the stylus rides the vertical contour and, when necessary, lifts the whole of the unit clear of the work for cleaning or inspection. An adjustable spring counterbalance system is employed to give light stylus pressure on the master.

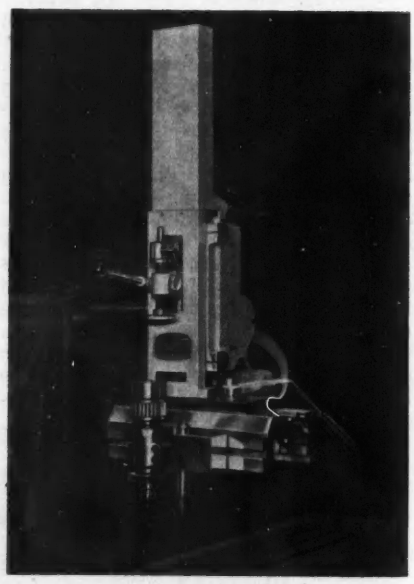


Fig. 62—"Silex" three-dimensional copying attachment for horizontal milling machines—Jones

The cutter spindle is fitted with a flywheel and has means of micrometer adjustment for height, the spindle having four speeds between 3450 and 8700 r.p.m. The stylus is secured in a holder which is adjustable for height of pattern relative to work. The duplicator is

simple to use and with it large dies can be sunk, the limiting factor usually being the longitudinal and cross movements of the milling machine table. In such cases the work is done progressively over sectional areas until the whole is complete. Depth setting facilities are provided adjacent to the ball-ended lifting handle for progressive roughing in transverse strokes of even depth until the bottom profile is reached. For similar use adjustable stops are provided for the transverse slides.

A Landis multi-wheel hydraulic grinding machine, which is demonstrated grinding camshafts, swings work up to 10in diameter, and uses any required number of wheels within a length of 30in to grind spaced diameters on a workpiece in a single operation. This machine (Fig. 63) has a built-in profile dresser for the wheels to enable the grinding of tapers and other shapes. The table-mounted diamond dresser is guided through profile bars mounted on the front of the bed when the table is traversed, and to reduce the dressing time to a minimum rapid traverse takes place between the wheels.

The wheel spindle is supported at each end in "Microsphere" bearings, which are sealed and pressure lubricated. A pressure safety switch in this lubricating system prevents the machine being operated unless a safe pressure is maintained at the bearings. Table traverse and wheel feed are hydraulically operated and the rates are adjustable. In the operating cycle the wheels are advanced rapidly to the work; they are then slowed to grinding feed rate and at the end of the grinding stroke retracted rapidly. Hydraulically operated back rests mounted on the table automatically move into position at the end of the rapid wheel advance stroke to support the work during grinding.

A redesigned No. 8 C.V.A. single-spindle automatic screw machine exhibited has a toothed timing belt drive which gives smooth slip-free transmission. A new gearbox on this machine gives eighteen turning speeds up to 7250 r.p.m. and 240 threading speeds. The change feed gearbox provides sixty-six cycle times from three-quarters to sixty-four seconds. Two other automatics, the No. 12 and No. 20, on the stand also incorporate a number of improvements to speed production and facilitate operation.

Coventry Gauge and Tool Company Ltd.,

Four interesting new "Matrix" machines

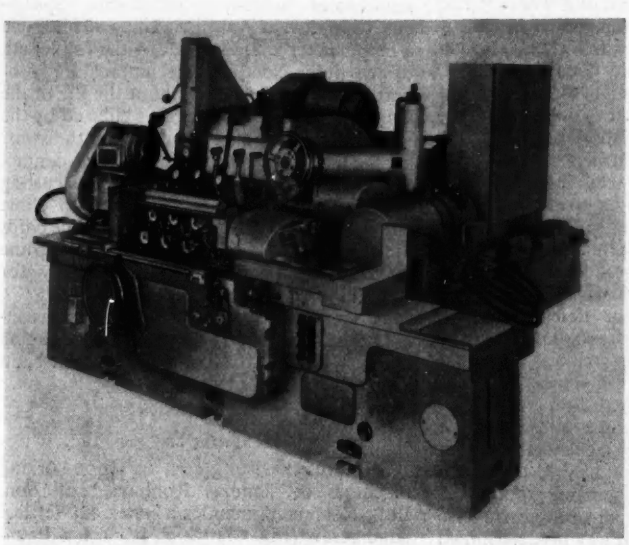


Fig. 63—Landis multi-wheel grinding machine exhibited with a set-up for grinding camshafts—Jones

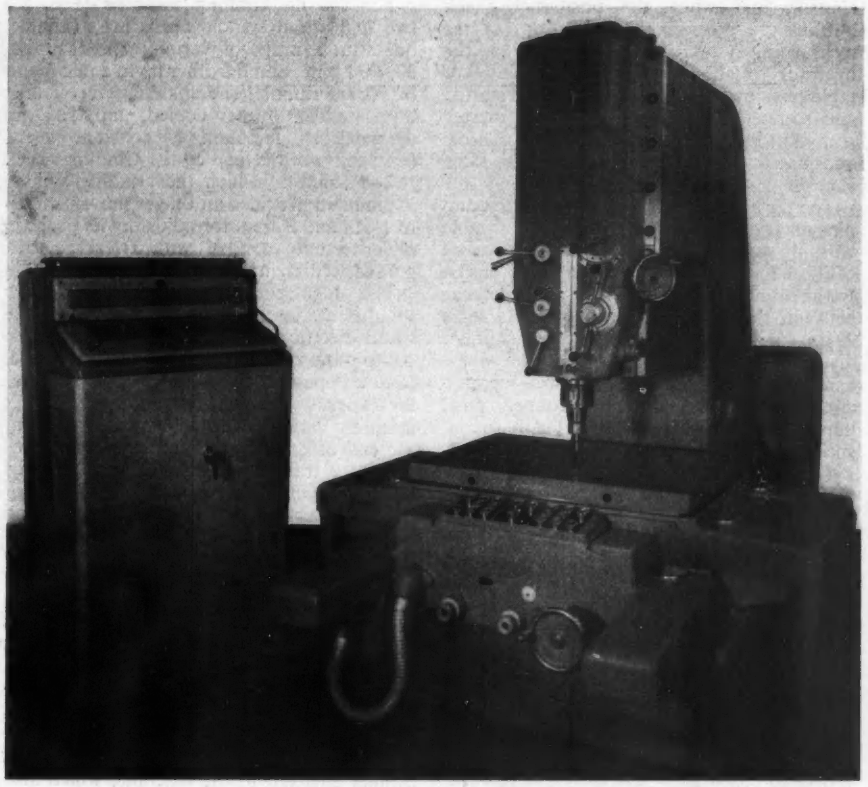


Fig. 64—"Matrix" No. 150 jig boring machine with electronic positioning equipment—Coventry Gauge

—a jig borer, a jig grinder, a gear grinding machine, and a No. 150 jig borer fitted with electronic positioning equipment—are shown on the stand of the Coventry Gauge and Tool Company, Ltd., Coventry.

The new No. 150 jig boring machine (Fig. 64) demonstrated is a development of the firm's No. 50 machine, and it has an electronic linear measuring system for positioning the table and push-button controls. The new equipment, which has been developed by the Mullard Research Laboratories, makes setting up simpler than before, and with it settings can be made in either direction to within 0·0001in.

For the electronic positioning system the internal standards of length are in the form of steel buttress scales, each of which consists of a solid steel bar having machined in it a sawtooth form of accurate 0·1in pitch. A step, machined lengthwise, reveals the form consisting of upright and sloping edges, and the maximum adjacent pitch error is 0·00002in.

Interpolation between the 0·1in steps of this master scale is accomplished optically, using a glass scale a little over 2in long which carries upwards of 1000 alternate opaque and transparent bars, equally spaced. These bars are scanned by a moving line of light and the projected image reduced optically by a factor of 20 so that 1000 bars fit exactly between adjacent vertical edges of the buttress scale. As the table is driven, the bars are counted as they emerge from behind a vertical edge by means of photo-multiplier tubes and an electronic counter. The number counted is subtracted electronically from the required number and the error displayed on a row of dial lamps. When the error is reduced to zero the central lamp of the row lights and the table is clamped by operating a push button.

Since 1000 units are counted when the table moves 0·1in each unit represents 0·0001in. To set the table it is only necessary to traverse within 0·1in of the required position, set three dials marked "hundreds," "tens" and "units," to the required number of ten-thousandths of an inch, and traverse slowly to reduce the displayed error to zero. The scales for both directions of table positioning are identical and provision is made so that the buttress scale can be shifted through 0·1in to allow an arbitrary origin of co-ordinates to be selected when the workpiece has been clamped to the table.

With the exception of the photo-multiplier tubes and their associated circuits all the electronic part of the system is mounted in a console separate from the jig boring machine.

The electronics console also houses contactor mechanisms, which, in conjunction with push buttons on the jig borer itself, control certain of the machine functions. For the rapid motion of the table in either ordinate, non-locking push buttons are provided which give a table speed of 36in per minute. On release of these buttons the table automatically stops and is clamped up. For slow motion, locking buttons are provided which give an adjustable table speed from 0·6in to 6in per minute. Locking buttons provide hand control of the table from a handwheel giving 0·01in of table motion per turn. A stop-and-lock button takes the table out of slow motion or hand control and clamps the table. In hand

control, and when the positional check buttons are pressed, the indications of the measuring system are displayed to the operator to allow setting and checking of table position. The boring spindle is started and stopped by push buttons. A master stop button switches off the entire console and machine with the exception of the table clamps.

The jig borer and the jig grinder are complementary machines, each having a table working surface of 18in by 12in with traverses of 12in longitudinally and 8in transversely. In the case of the borer the maximum distance between the spindle nose and the table is 22½in, and on the grinder the maximum distance between the bottom of the wheel and the table is 16in. Power-operated controls, actuated through grouped push buttons, fitted on the machine facilitate and speed setting operations.

Longitudinal and transverse table movements are effected by ground thread lead screws and it incorporates a corrector bar system to ensure precision settings. Each slide movement is operated by an individual electric motor, an overload clutch being fitted to avoid damage to the lead screws and an automatic brake prevents over-run. Setting movements of the slides are made by approximate positioning through the rapid push-button controlled drive and final pre-

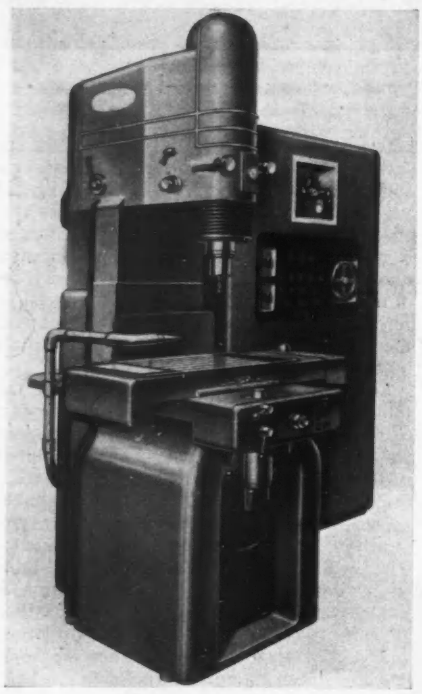


Fig. 65—Jig grinding machine with push-button-controlled power slide setting—Coventry Gauge

cision setting by hand control knobs with reference to large dials reading to 0·0001in direct by vernier.

In the jig boring machine the spindle head is mounted on a power-operated vertical slide controlled by a push button on the apron of the machine, and it has a 16in travel. The spindle is driven by a variable speed a.c. motor, giving from 100 to 3000 r.p.m., and it has three feed rates of 0·001in, 0·0016in and 0·0025in per revolution. In addition to the power feeds, both rapid and fine hand feeds are provided. A cabinet at the side of the machine houses the control equipment and also provides accommodation for tools and other accessories.

For the jig grinding machine (Fig. 65) two high-speed spindle heads are available, one with a range of variable speeds up to 60,000 r.p.m., and the other up to a maximum of 90,000 r.p.m. The spindles are oil mist lubricated and water cooled, and they are designed to maintain a constant speed irrespective of the load on the grinding wheel. A cross-slide in which the grinding spindle is mounted provides an off-set movement up to 1 1/16in and is used for adjusting its position under remote control with reference to a graduated dial on the head.

The high-speed quill into which the spindles are inserted is rotated by a variable speed electric motor providing a range of 40 to 400 r.p.m., and 4in vertical travel can be power or hand-operated to suit the work. The power traverse speed is infinitely variable with a controlled dwell at the end of each stroke and means are provided for traversing the quill to the top of its stroke without disturbing the setting of the traverse stops. This enables gauging and inspection to be carried out with the minimum loss of production time. Hand rotation of the quill can also be effected for segmental grinding through a predetermined arc and a graduated control dial enables this operation to be performed to a high degree of accuracy. The quill can be inclined in its sleeve up to an angle of 1½ deg.; this gives control for parellelism and enables holes to be ground up to 3 deg. included taper.

The speed controls are housed in a control cabinet adjacent to the machine, which also houses a dust extractor unit and acts as a junction for coupling the oil and mains water supply. An interlock prevents the spindle from being started without cooling water or oil mist lubrication.

A new gear grinding machine (Fig. 66) has been developed by this firm for the production of small instrument and fine pitch spur gears from solid hardened blanks. It is capable of grinding any number of teeth, from twelve to 192, without the use of indexing plates, ranging from 16 D.P. to 100 D.P., or Module 1·6 to Module 0·25 and it admits work up to 6in diameter and 9in long between centres.

The wheel-head is driven by balanced dual motors in the base of the machine, one motor provides the grinding speeds and the other wheel-dressing speeds. The machine has been designed for spur gear production but its wheel-head can be inclined to a slight angle to compensate for the helix angle of the spiral ribs of the grinding wheel. The standard 1in wide grinding wheel can, if required, be replaced with wheels up to 1½in wide, so that should conditions allow, a wider wheel can be used first to rough out gears, using a portion of the wheel and finishing them with the unused portion. The wheel-head feed is controlled by a hand-wheel which can either feed the wheel into the work or withdraw it to the dressing position, indicators being provided to warn the operator when grinding and wheel forming positions have been reached.

Enclosed within the work head assembly are the change gears for determining the number of teeth and the gears governing the rate of feed. The unit includes the main slide upon which the headstock is built, whilst the tailstock is movable on guide ways. The work head centre can be adjusted to run concentric with the work head spindle with the aid of a sensitive indicator to ensure concentricity of the gears being ground. A lever used for engaging the power traverse can be set to withdraw at any predetermined position.

Instruments of interest shown by the firm include a height setting micrometer, which enables accurate height settings and measurements to be taken from surface or machine tables. By turning the micrometer sleeve of this instrument settings to 0·00001in. on the vernier scale are immediately available It is basically a substantial casting housing a highly accurate slide which runs on anti-friction slideways. The slide carries a set of standard slip gauges which are wrung together to give increments of 1·0000in

Fig. 66—Grinding machine for the production of small spur gears for instruments directly from hardened steel blanks—Coventry Gauge

from zero to 12in. The movement of the slide is controlled by a micrometer graduated in 0·0001in divisions with a vernier reading to 0·00001in. The slide which carries the slip gauges has a travel of 1½in which allows the top of the lowest gauge to be set level with the base of the instrument. Settings may be taken from either the upper or lower surfaces of the gauge blocks.

Firth Brown Tools, Ltd.

In addition to showing the engineers' cutting tools of all kinds which it makes, the firm of Firth Brown Tools, Ltd., Carlisle Street Works, Sheffield, is giving demonstrations of the recently introduced "Speedicut Chipbreaker" drills. These drills have a chipbreaker rib milled along the full length of the flutes, so that the chipbreaking properties are retained throughout the life of the drill. With the drills the cut is effected by the full length of the cutting edges and the swarf sliding down the face of the flutes contact the ribs. The ribs impart a light curling action, which breaks the metal into short chips. The short lengths into which the chips are broken allow them to flow freely up the drill flutes and there is no tendency for the drill to clog.

This firm is also exhibiting a drill sharpening machine, a circular saw sharpening machine, and a "Crypto-Atlas" metal band sawing machine for bar stock.

Thomas Robinson and Son, Ltd.

A representative group of woodworking machines of Thomas Robinson and Son, Ltd., Rochdale, includes a new 54in vertical band resaw (Fig. 67) which has a maximum depth of 16in under the top saw guide, a maximum setting width of 6in between the

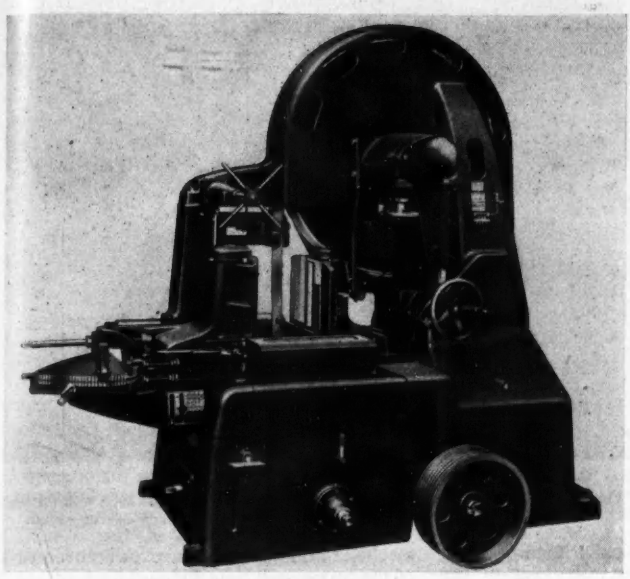


Fig. 67—54in vertical band resaw machine with four-roller, self-centring feed gear—Robinson

saw and gauge rollers, and 12in between the saw and left-hand feed rollers.

This machine takes saws up to 7in wide and its roller bearing mounted saw wheels are driven by a 50 h.p. motor. Six rates of feed, available through the gearbox, are between 30ft and 180ft per minute, or, alternatively, 40ft and 240ft per minute. A built-in power rise and fall mechanism for the top wheel is driven by a ⅓ h.p. motor. The four 7in diameter vertical in-feed rollers have screw and lever means of adjustment and are arranged to operate as simultaneous double pressure rollers for automatically centring the timber. Alternatively, the right-hand pair can be locked to become powered gauge rollers with the left-hand pair remaining as powered pressure rollers. The left-hand in-feed rollers are independently spring-loaded or locked in line.

The feed roller assemblies are mounted on anti-friction slides and the whole feed assembly is adjustable in the direction of the feed to keep pressure point near the saw teeth and provide a firm hold for timber being cut. A pedal-operated simultaneous opening movement is provided to both pairs of feed rollers if set for centre-sawing, or to the pressure rollers only, if gauge sawing. The whole feed assembly can be tilted up to 10 deg. for bevel sawing, with no re-adjustment needed to either the feed drive tightener or foot control pedal.

A new 18in tilting spindle saw-bench shown is designed for ripping, cross-cutting, mitring and grooving to fine limits. Its saw, which is driven by a 7½ h.p. motor mounted directly on the spindle, can be tilted up to 45 deg. and has a 5¼in depth of cut. The table is made in two machined and aligned parts, the front part being carried on rollers, on which it is moved smoothly and easily past the saw.

H. W. Ward and Co., Ltd.

The capstans and turret lathes shown by H. W. Ward and Co., Ltd., Selly Oak, Birmingham, 29, have been made by the firm for some years and with possibly a few minor modifications are similar to those exhibited in 1952. The combination turret lathes, four of which can be seen upon the stand, are now equipped with hydraulically operated driving clutches which gives an easy finger tip gear change.

One of the "No. 7" combination turret lathes (Fig. 68) is fitted with hydraulic pre-selecting speed changing mechanisms, which also enables speed and direction of rotation to be changed simultaneously. For this "Preselector" mechanism two concentric dials are mounted at the front of the headstock. One dial is graduated for the speed range and the other is marked with three positions, with symbols indicating "forward," "reverse," and "free." These dials can be set as required whilst the machine is running and, when required, operation of a single lever on the top of the headstock engages the necessary gears.

This No. 7 combination turret lathe takes 2½in bar and swings up to 16in over the bed covers. It is built with adequate capacity for use with tungsten carbide tools and has twelve speeds from 25 to 1000 r.p.m. in both directions of rotation. The saddle has automatic sliding, surfacing and screwcutting motions, four stop positions being fitted for each direction of surface feed, and six stops for longitudinal saddle movements. Ten rates of turret saddle feed are provided.

Two of the firm's larger combination turret lathes are shown, one with a 4¼in hole through the spindle and capable of swinging up to 23in over the bed, the other taking a 5in bar swings up to 29in over the bed covers.

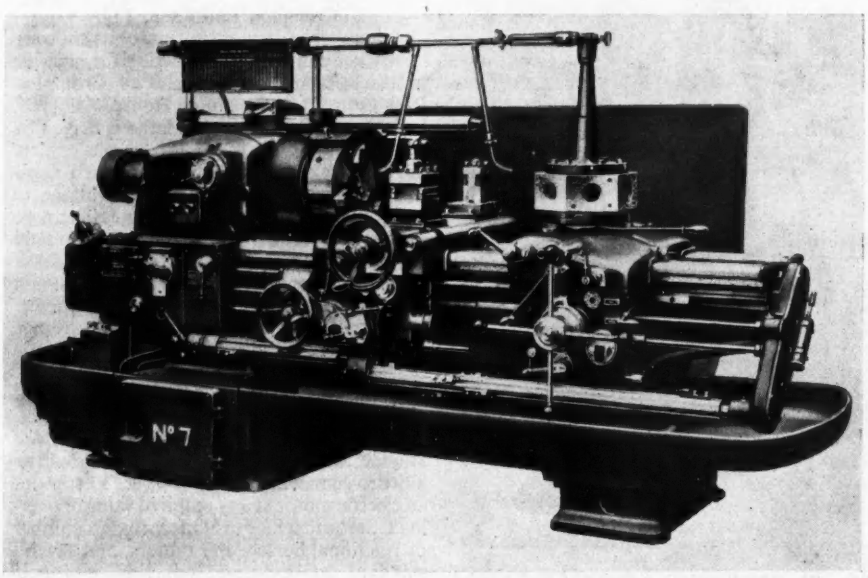


Fig. 68—No. 7 combination turret lathe with hydraulically-operated speed changing mechanism—Ward

Electric Resistance Furnace Company, Ltd.

The Electric Resistance Furnace Company, Ltd., Queens Road, Weybridge, Surrey, is drawing particular attention to applications of the "Corrtherm" heating element developed by the firm and its associate company, the Lindberg Engineering Company of the United States. This element is shown

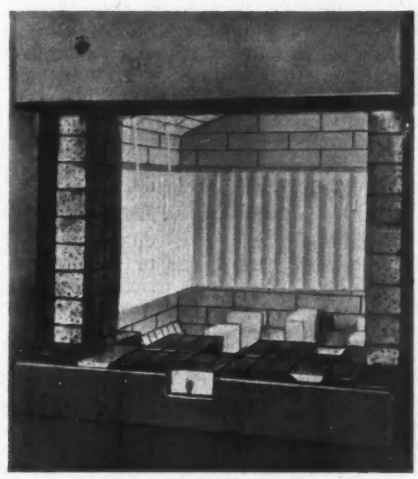


Fig. 69—"Corrtherm" elements in a box atmosphere furnace—Electric Resistance

fitted in a standard controlled atmosphere furnace as used for gas carburising, carbo-nitriding, bright hardening and bright annealing. The furnace, with a charge space 24in long by 12in wide and 10in high, is rated at 20kVA.

"Corrtherm" elements consist of corrugated sheets of nickel chromium which are unaffected by carburising gases. The sheets are hung from alloy hooks extending down from the furnace roof, and they can be arranged to cover practically the entire wall area. No supports or hangers need to be built into the walls to support the elements as the corrugations give sufficient strength and rigidity. These corrugations, which provide a greater length of material and increased resistance, can be spaced to vary the heat release along the length of a furnace to compensate for door heat losses or incoming cold work.

The makers point out that, although carbon deposition cannot be prevented in gas carburising furnaces, the voltage in the furnace is so low that there is no leakage through such deposition. Actually, it is stated, the oxide coating which forms on the surface of an element is sufficient to confine the current to the element even when it is covered with

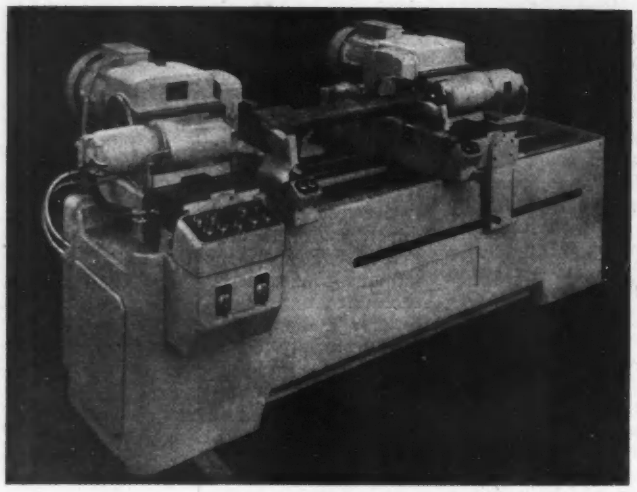


Fig. 70—Hydraulically-operated automatic cycle facing and centring machine for bars, billets or forgings—Jones

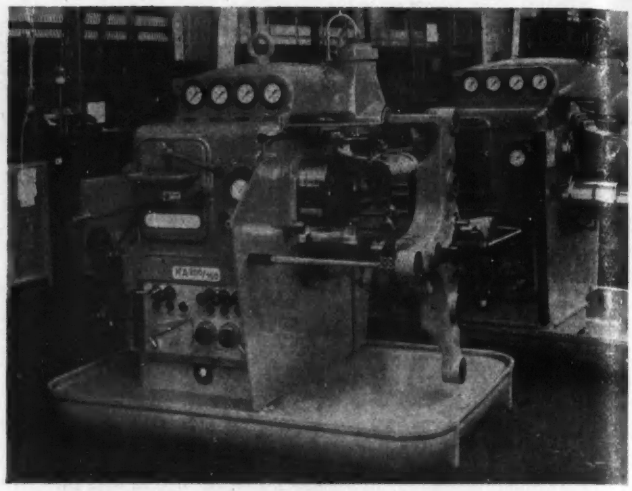


Fig. 71—Monfort horizontal chucking automatic with hydraulic control and indexing. It turns work up to 10in diameter over a length of 7in—Jones

soot. A high temperature enamel is fired on each element, and because of the low voltage used accidental contact with an element when loading or unloading a furnace does not affect the operator.

In the case of very large furnaces elements can be suspended between the rows of work as well as round the walls, and if desired different temperatures can actually be applied in different rows of work. In forced convection furnaces, where fans circulate the atmosphere through the charge, the elements can be arranged to act as direction baffles. A furnace chamber fitted with "Corrtherm" elements can be seen in Fig. 69.

Sidney G. Jones, Ltd.

A high-speed facing and centring machine for preparing bars, billets or forgings for turning on copying lathes which is made by Douglas Fraser, Ltd., of Arbroath, is amongst the machines on the stand of Sidney G. Jones, Ltd., 8, Balham Hill, London, S.W.12. It is designed to handle work up to 6½in diameter and is made with three bed lengths taking work up to 60in, 84in and 108in long respectively. As can be seen in Fig. 70, the machine has a rigid bed on which are two opposed units on transverse slides and incorporating a milling head and a centring head; and complementary self-centring vices can be attached to or separated from the transverse slides. The left-hand unit is stationary on the bed, whilst the right-hand unit can be adjusted along the ways to suit the length of the work.

This machine can be set to face and centre both ends of the work simultaneously, or to face and centre one end only, or to centre or to mill only at either end. Each milling head is driven by a 5 h.p. motor and takes 9in cutters; the centring heads are driven by ½ h.p. motors and the quill feed spindles have a hydraulically operated stroke of 1in at up to 10in per minute. Transverse movement of the units for the face milling operation is hydraulically operated at up to 15in per minute. The self-centring vices are also hydraulically operated and their clamping load is adjustable.

When the work has been loaded and clamped in the machine the operating cycle can be started on depression of a push button. The milling spindles start and the heads move at fast traverse speed to the work, changing to the cutting feed rate at the preset work position. At the completion of the milling pass the milling spindles stop and the units retract at high speed to the drilling position. The drilling spindles then start and the heads approach at rapid traverse speed, which changes automatically to slow feed for drilling to depth. At the end of the drilling operation the heads retract at high speed and the spindles stop, completing the automatic cycle, when the vices can be opened for changing the workpieces.

Among the machines of continental manufacture exhibited on this stand is the Monfort chucking automatic shown in Fig. 71, which is designed for turning work up to 10in diameter over a length of 7in. This machine has a hydraulically operated automatic cycle. Its heavy headstock spindle, driven by a 7 h.p. motor through a P.I.V. gearbox and multi-disc clutches, has two-speed ranges giving steplessly variable speeds from 65 to 1350 r.p.m. The three-jaw clutch normally used is operated by a hydraulic clamping cylinder fitted in the rear of the main spindle.

The cruciform turret is supported on a heavy central shaft parallel to and below the main spindle, and it carries a tool slide with four faces. During the inward working stroke of this turret the upper arm registers in a hardened index bar on which it is accurately guided. Two cross slides, one vertical and one horizontal, work independently of each other, and they are used for facing, grooving and relieving operations, whilst the tools on the main turret slide do the longitudinal machining on the workpiece. All movements of the turret and cross slide are hydraulically controlled at steplessly variable speeds. The working strokes and indexing movements are controlled and limited by the setting of screw stops on a control drum at the rear end of the turret shaft.

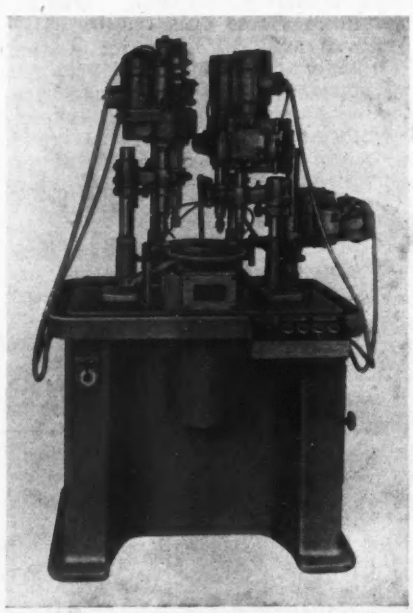


Fig. 72—"Variomatic" indexing table machine for small precision component manufacture—Jones

A Wälztechnik worm milling machine exhibited is designed for conventional and climb milling and the distance between its 6·3in high centres is 20½in. It mills worms and threads from 1in to 12in diameter and up to 17½in long, with leads from 0·120in to 16in. The largest diametral pitch machined using a disc cutter is 0·85 D.P. and with an end mill 1·25 D.P.

Hahn and Kolb, of Stuttgart, make an indexing table machine known as the "Variomatic," which is built up of standard units and can be arranged in a number of different ways for the production of small precision parts. A typical machine of this kind is illustrated in Fig. 72. It consists of a central automatic indexing unit on which is mounted the work table carrying the necessary clamping jigs. Pillars arranged round the table support standard drilling, tapping, milling or sawing heads. The work strokes of the spindles in the heads are controlled by a camshaft in the indexing unit, directly through levers or solenoid switches, between each indexing movement.

Crompton Parkinson, Ltd.

A number of demonstration units showing systems of control and protection formachine tool drives are on the stand of Crompton Parkinson, Ltd., Crompton House, Aldwych, London, W.C.2. In one a lathe is driven by a ½ h.p. motor, arranged for simple control of speed by means of a hand-operated regulator, which causes the armature voltage to vary, giving motor speeds up to 1500 r.p.m. at constant torque. At higher speeds a field rheostat comes into action and provides a constant horsepower output. This combination of constant torque and constant horsepower characteristics is designed to drive the average machine tool with variable speed over a wide range in the most economical manner.

A variable overload device demonstrated consists of the recently introduced contact-making ammeter, an inexpensive device, which affords reliable overload protection for electrically driven machines. It can be set to trip out an electric motor at any required value of overload. Static machine exhibits include a number of fractional horsepower motors, and several standard squirrel-cage induction motors.

(To be continued)

High-Voltage Power Systems

C.I.G.R.E. MEETING IN PARIS

No. III—(*Concluded from page 704, June 22nd*)

The sixteenth meeting of C.I.G.R.E., the international conference on large high-voltage power systems, was held at the Fondation Berthelot, 28, Rue St. Dominique, Paris, from May 30th to June 9th last, and was attended by delegates from forty-three countries. In the first article of this series we gave a resumé of the discussion on papers dealing with transformers and overhead lines. Last week's article dealt in a similar way with insulators, alternators, circuit breakers and cables. In conclusion we summarise those sessions of the conference that were concerned with system stability, high-voltage d.c. transmission, and trends in the use of extra-high-voltage a.c. for power transmission. An outline is given of 380kV, a.c. systems in Sweden, Russia, Germany and Finland.

Power System Stability

THE stability of large power systems and the operational control of voltage, load and frequency were discussed, under the chairmanship of Mr. S. B. Crary (U.S.A.), in one of the C.I.G.R.E. sessions held on Tuesday, June 5th. Eight papers covered the first main topic for discussion, which was frequency control with tie-line load bias.

The discussion was opened by Mr. S. B. Morehouse (U.S.A.), author of the paper describing recent developments in the automatic control of large interconnected power systems in the U.S.A. He outlined the principles of area control which depended on the forecasting of load demands in given areas and on the expected demands from different classes of consumers ; on this basis the system as a whole was operated with the optimum economy and simplicity of control. Since so many variables were involved in attempting a theoretical solution, and so many assumptions had to be made, Mr. Morehouse said that he preferred a more practical approach.

Tests done two years ago on a tie-line between France and Belgium were described by Mr. F. Denis (Belgium). In those tests the frequency and load at the receiving end of the line were recorded continuously and transmitted to four power stations where the required regulation was carried out. It was proposed to do a further series of tests in which the data would be transmitted to a greater number of power stations, both in France and in Belgium. Nearly half of the total capacity of Belgium would be involved in the tests and about 80MW of that total would be subject to automatic control.

Mr. A. Malme (Sweden) discussed the influence of governor time-lag on regulation. He referred to the proposal that an integrating function should be introduced into the governing characteristic and went on to describe an electro-hydraulic governor : its dead time was effectively nil and it did not require an integrating characteristic. A time-lag of about one second in governor response had proved to be satisfactory and cheap and simple equipment could be used. Frequency stabilisation limits had been relaxed from $\pm 0{\cdot}05$ c/s to $\pm 0{\cdot}1$ c/s, and the result was tolerable to the consumer.

Referring to Mr. Morehouse's paper on American practice, Mr. F. Cahen said that there was no disagreement about the methods to be used or about the required percentage of rotating plant reserve, which seemed to be much the same in Europe as in the U.S.A. The essential difference was in the existence of the European political boundaries.

Mr. E. B. Powell (Great Britain) made a reference to his paper on the analysis of turbo-alternator performance by stroboscopic methods of measuring the angular displacement of the rotor under load. Experience with that instrument indicated that it could be applied to a number of interconnected machines so that deductions could be made about the stability of the system as a whole at various load conditions.

Mr. Venikof (U.S.S.R.) commented on the use of micro-networks and models as a means of tackling stability problems, provided that the behaviour of the model could be closely related to that of the actual network. To obtain information for the design of the Moscow-Kuibyshev system experimental work had been done on a miniature network with a power loading equal to that of a small industrial installation. They had developed new regulators which took into account power and frequency as well as the first and second derivatives of those parameters. Five different kinds of analysers had been built and between them they covered most of the electrical and hydraulic problems that required solution. A micro-network for very-high-frequency operation was under development.

The second phase of the discussion was concerned with five papers on series capacitors. Mr. P. R. Coursey (Great Britain), who opened the discussion, referred to the influence exerted on capacitor design by the introduction of synthetic liquids as an alternative to mineral oils. A synthetic liquid, such as " Arochlor," was able to withstand electrical stresses 90 per cent above those permissible with mineral oils. The consequent reduction in size was particularly attractive to the makers of small capacitors.

Discussing the comparative economics of series capacitors, shunt capacitors and synchronous condensers, Mr. S. Lalander (Sweden) said that it was generally cheaper to provide reactive power at the sending end of a line. If that fact were taken into account it would be found that the series capacitor was not necessarily the best alternative.

Dr. J. R. Mortlock (Great Britain) commented on the use of single-phase, high-speed automatic reclosing. The main trouble with single-phase reclosing was caused by the capacitance current which was transferred to the disconnected line by the two healthy phases. Interruption of that residual current was usually effected by a long arc which was naturally self-extinguishing under normal atmospheric conditions. Describing some work on this subject Dr. Mortlock said that four main factors had to be considered. They were : first, the magnitude and duration of the fault current; secondly, the residual current that would flow in the fault path after the conductor had been isolated at both ends ; thirdly, the residual voltage that would appear across the fault path after the successful clearance of the fault current, and, fourthly, the restriking transient associated with the residual current. Dr. Mortlock described a model circuit that was used to determine those four factors and a test circuit which could accurately simulate the conditions. It required only a small fraction of the voltage needed for the full-scale system, say, 25kV in the case of a 330kV system.

High-Voltage D.C. Transmission

The development of power transmission by high-voltage direct current was discussed on Friday, June 1st. Mr. B. Rathsman (Sweden) was chairman for the session and Mr. F. J. Lane (Great Britain) was the special reporter.

One of the papers under discussion was presented on behalf of the C.I.G.R.E. study committee by Messrs. F. J. Lane, B. G. Rathsman, U. Lamm and K. S. Smedsfelt. This small working group made a study of transmission costs for high-voltage a.c. and d.c. systems. Their conclusions are summarised in the following abstracts from the paper.

Transmission Costs for A.C. and D.C.

Substantial development has taken place in recent years both in the d.c. field and in the a.c. field. A first commercial h.v., d.c. transmission between two a.c. systems has been developed and placed in regular operation in Gotland, Sweden, with a capacity of 20MW at 100kV d.c. Parallel trials in the laboratories have shown that it is quite possible to build converters for considerably higher voltages than 50kV, which is the rating of the Gotland converters, and with an operating reliability which is quite acceptable for transmission.

In the Soviet Union an experimental d.c. transmission, operating with 200kV, 30MW, over a distance of 112 km, has been in trial operation since 1951. Two cables are used for the transmission which normally operates without earth return. The operation is reported to have been gradually improved and to be quite reliable. Large commercial h.v., d.c. transmissions are being studied with a view to being realised in the reasonably near future. H.v., d.c. transmissions seem to be very promising for the important long-distance transmissions needed to connect the big power centres of the country.

Basic Assumptions.—Two main types of transmission have been studied, the one using overhead power lines and long transmission distances, 300–1000km and up to 1500MW capacity, and the other with submarine cables and distances of 30–100km and up to 750MW. The principal data for the transmissions with d.c. and a.c. compared here are in Table I.

In the selection of these capacities a.c. transmission of the highest voltage at present adopted, i.e. 400kV, has been taken as a starting point. The most economical load for a long 400kV transmission compensated with series capacitors is about 750MW. Such a transmission for 400kV, 750MW, therefore represents about the lowest transmission cost per kilowatt, which can be realised with the present a.c. technique.*

This a.c. case is compared with a d.c. transmission of the same capacity carried on a two-wire overhead line. The two wires carry $+300$kV and -300kV respectively, i.e the midpoint is at earth potential. This d.c. voltage 2×300kV should be a reasonably economical choice, although it has not been confirmed by numerical calculations.

It should be observed, however, that the two-wire d.c. transmission of 750MW is superior to the single-line a.c. transmission of the same rating as regards dependability of service. If the d.c. transmission is disturbed by an insulator or conductor failure or a fault in the terminal station equipment of one-half, the transmission can go on operating on the other half, thus carrying at least half the rated full capacity. On the single-line a.c. transmission such faults generally cause a complete interruption of the power flow. In this respect the two-wire d.c. transmission is similar to a double-circuit a.c. line for 2×375MW, having in all six conductors, which is, of course, more expensive than the

TABLE I—*Main Data of the Investigated Transmission Cases*

	D.C.				A.C.			
	Case	MW	kV	Number of series connected valve groups per station	Case	MW	kV	Number of parallel lines or cables per phase
Overhead line	D1	2×750	2×400	2×4	A1	2×750	400	2
Overhead line	D2	2×375	2×300	2×2	A2	750	400	1
Submarine cable ...	D3	2×375	2×300	2×2	A3	750	220	2
Submarine cable ...	D4	1×200	200	2	$A4_{130}$	200	130	1
				2×2	$A4_{220}$	200	220	1
Submarine cable ...	D5	1×100	200	2	A5	100	130	1

* Further reduction of a.c. transmission costs is to be expected as still higher voltages come into use in the future.

single 750MW a.c. line. The d.c. line is, however, not necessarily equivalent to the double a.c. line as the latter is frequently so dimensioned that after a fault on one branch the other one alone can temporarily carry the full load, while the capacity of the d.c. line will be more restricted unless the terminal equipment has been purposely overdimensioned. Further, the running of the d.c. transmission on one pole only is also restricted to the case in which the earth can be allowed to carry the return current. Extensive investigations which have been carried out in recent years indicate that such an earth return should generally be practicable without inconvenience, especially for short periods of time.

In some instances, therefore, the two-wire d.c. line possesses a considerable economical advantage over a single three-phase line and, even if it is not fully equivalent to a double three-phase line for the same total capacity, it would be justifiable in some cases to compare it with a double a.c. line of this kind. This is done in the first cases D1-A1 shown in Table I, where a 1500MW, 2×400kV, d.c. line is compared with two parallel a.c. lines, each for 750MW at 400kV, a.c. These cases represent conditions where a relatively large block of power has to be transported over a long distance.

In one case of cable transmission the same data, 2×375MW and 2×300kV, as for one of the overhead transmissions, have been chosen for the sake of comparison. Considerations of cable design and laying have led to the choice of 220kV for the a.c. cables ; 2×3 cables are required, as against two cables for d.c. As the cost of a sea return arrangement is low, this case also affords a conception of the cost of a single-pole 375MW, d.c. transmission.

Three cases of smaller capacity for submarine transmissions have also been investigated.

TABLE II—*Annual Costs in Swedish cr. for 700km Overhead Line Transmission* (1955 *prices*)

Case	D.C.		A.C.	
	D1	D2	A1	A2
Capacity (MW)	2×750	2×375	2×750	750
Voltage (kV)	2×400	2×300	400	400
Stations	16·40	8·20	9·1	5·50
Line	7·90	5·85	17·8	8·90
Losses :				
Stations	5·70	2·85	2·2	1·1
Line	6·15	4·05	10·7	5·35
Corona	0·10	0·10	0·7	0·35
Total cost in million Sw. cr.	36·25	21·05	40·5	21·2
Specific cost in Sw. cr. per kW, 100km and year	3·45	4·0	3·86	4·04
Specific cost in case the transmission is not from 20kV to 130kV but :				
From 220kV to 220 kV	3·54	4·10	3·86	4·04
From 400kV to 400 kV	—	—	3·2	3·2

Total Transmission Costs.—The total transmission costs for the different transmission systems have been calculated by combining the annual costs for the installations and the losses costs. As an example of the manner in which these costs are composed, specifications are given in Tables II and III, both for 700km overhead line transmission and a 60km submarine cable transmission.

Conclusions.—Local conditions as to geography, economy, technical practice, &c., may considerably influence the absolute and comparative costs of a.c. and d.c. transmission for a specific project. With this reservation the authors think that this study gives a dependable general indication of the competitive qualities of the d.c. and a.c. systems and justifies the following general conclusions :

(1) As the d.c. transmission is characterised by lower line and higher station costs than for the a.c. system, the d.c. system calls for a certain minimum transmission distance to become competitive. Consequently, the distance of equal costs is influenced by all conditions affecting these cost relations, for instance, abnormal obstacles for line building.

(2) For an overhead-line straight-through transmission from a power plant to a receiving a.c. network the cost curves for a.c. and d.c. intersect at 530km (320 miles) for 1500MW and at 650km (390 miles) for 750MW transmission capacity. For a similar transmission between two a.c. networks the curves intersect at fifty distances to 100km (30 to 60 miles) greater.

(3) As to hazards of line interruption, the a.c. alternative is somewhat superior to the d.c. solution in the case of 1500MW capacity (two independent lines against two independent d.c. poles carried on the same towers), whilst the d.c. transmission is superior in the case of 750MW capacity (single line against two independent d.c. poles) provided the earth can be used as a return conductor.

(4) For a submarine cable transmission the cost curves for a.c. and d.c. intersect at 37km (22 miles) for the transmission of 750MW, at 43km (26 miles) for 200MW and at 30km (18 miles) for the smallest capacity, 100MW.

For a similar transmission connecting two a.c. networks the critical distances are somewhat greater, namely, 52km (31 miles) for 750MW, 52km (31 miles) for 200MW, and 35km (21 miles) for 100MW.

In the case of a mixed overland and submarine transmission, d.c. can be economically justified even where the width of the water to be crossed is lower than the critical distances mentioned above, if the same d.c. can be used for a considerable length of overhead line.

(5) Apart from the direct cost comparison, the following characteristics should be mentioned in favour of d.c. As the d.c. link is not a synchronous one the regulation of the power flow can be effected independently of the frequency and voltage of the connected a.c. networks. This facility may be of considerable economical importance. D.C. cables are believed to have a longer life than a.c. cables, which are more subjected to dielectric fatigue and over-current stresses. Short-circuit stresses in connected a.c. networks are reduced.

(6) On the other hand, the d.c. transmission has the following disadvantages. Because of the relatively high cost for the converter stations intermediate connections to a long-distance transmission are less desirable than for an a.c. transmission. Protection of telecommunication circuits against disturbances from harmonics may in some cases cause extra precautions and costs.

(7) Both for the d.c. and a.c. system further technical development with related cost reductions are to be expected. As the d.c. system as related to high voltages represents a more recent technique the development should be expected to result in relatively larger savings than for the a.c. system.

TABLE III—*Annual Costs in Swedish cr. for 60km Submarine Cable Transmission* (1955 *prices*)

Case	D.C.			A.C.			
	D3	D4	D5	A3	$A4_{130}$	$A4_{220}$	A5
Capacity (MW)	2×375	200	100	2×375	200	200	100
Voltage (kV)	2×300	1×200	1×200	220	130	220	130
Stations	8·5	3·0	1·95	2·82	0·46	1·15	0·41
Cable, laying included	2·32	0·75	0·46	12·30	4·60	5·45	4·60
Electrode and line	—	0·03	0·02	—	—	—	—
Losses :							
Stations	2·96	0·96	0·59	1·06	0·16	0·31	0·07
Cable	0·80	0·35	0·19	3·42	1·28	0·91	0·47
Electrode and line	—	0·15	0·08	—	—	—	—
Total cost in million Sw. cr.	14·58	5·24	3·29	19·60	6·50	7·82	5·55
Specific cost in Sw. cr. per kW, 100km and year	32·5	43·5	54·8	43·6	54·0	64·5	92·0
Specific cost in case the transmission is not from 20kV to 130kV systems but :							
From 130kV to 130kV	33·8	44·7	56·0	43·6	51·5	64·5	89·0
From 220kV to 220kV	33·8	44·7	56·0	37·4	57·2	59·0	94·0

DISCUSSION

Mr. T. Yamada (Japan) said that his country was particularly interested in d.c. transmission because of the attraction offered by submarine cable links between the four main islands, and, possibly, some of the many smaller islands. Some of the projected transmission links he mentioned were :

(*a*) Between Yakushima (an island south of Kyushu) and Kyushu, transmitting at first 50MW at 50kV and, later, 100MW at ±100kV over a distance of about 100km.

(*b*) Between Kyushu (60 c/s) and the island of Jakashima (50 c/s), transmitting 7·5MW at 60kV over about 5km, by means of a d.c. submarine cable. It was hoped that this scheme would be started in the near future.

(*c*) Between Honshu and the island of Sadogashima, to transmit 5MW over about 60km.

(*d*) Between Shikoku and Honshu to transmit 100MW over about 130km, including 5km of submarine cable.

Mr. W. Casson (Great Britain) suggested that, since estimates of the basic costs had been given, manufacturers should try to estimate the reductions that might be made if bulk orders were placed for equipment. In a comparison of d.c. and a.c. schemes using submarine cables the importance of a spare cable should be remembered because with d.c. transmission it could be used to take some of the load from the other cables. He did not think that d.c. was better than a.c. for making emergency transfers of power : for although the Gotland cable had transmitted power in both directions there was no mention of reverse power transmission in the paper describing the Russian experimental 200kV system. Mr. Casson observed that a three-wire d.c. circuit, 300kV to earth, could transmit about 1800MW, compared with 750MW for a similar a.c. line. With the growing difficulties of obtaining wayleaves for overhead lines in Great Britain, d.c. transmission provided a way of doubling the capacity of existing lines. He thought that the extra cost of the fixed equipment needed might be about equal to that of a new reinforcing line.

Mr. Rokotjan (U.S.S.R.) made a brief reference to the experimental 200kV, d.c. transmission system between Kashira and Moscow, which was commissioned in 1950. The line was 112km long, with a capacity of 30MW, and, besides providing an additional link between the Kashira power station and the Moscow power system, it constituted the main experimental line for Russian studies of d.c. power transmission. The link consisted of two single-core underground cables, each consisting of an oil-impregnated, paper-insulated aluminium conductor of 150 square millimetres cross section. The lead sheath was protected by p.v.c. and rubber tapes, with steel wire armouring. Conversion from a.c. to d.c. at Kashira and inversion from d.c. to a.c. at Moscow was effected by grid-controlled mercury-arc rectifiers. At the converter and inverter stations the basic arrangement consisted of a bridge connection with three mercury-arc equipments in series forming each arm of the bridge. In five years of operation about 600 million kWh had been transmitted. Despite the absence of spare rectifier groups at both terminal stations the system performance had been stable. The longest uninterrupted transmission period had been over 1000 hours in 1955. A much more ambitious project for the transmission of 2000MW by d.c. over a distance of 2000km was being studied.

Mr. S. Lalander (Sweden) said that the case for d.c. was strongest when it was required to transmit large blocks of power over distances of 500km or more. In Sweden d.c. transmission would have to be competitive with the existing extensive a.c. system bulk transmission. Conversion to d.c. working would be very expensive, but, in the case of several 200kV lines working in parallel with the 400kV system, it might be economic to change to d.c., with the prospect of achieving better loading.

Mr. R. C. Mildner (Great Britain) examined the

prospects of using plastics-insulated cables for high-voltage working. He thought that d.c. interference with ships' magnetic compasses could be eliminated by using a twin-pair cable which could be made for service at 200kV to earth. A 100kV plastics-insulated cable was undergoing tests in air and under water.

Stressing the need for further research Mr. Rabinowitz (U.S.S.R.) referred to fundamental work that was being done on lines and insulators in Russia. Flashover characteristics were being studied at voltages up to 1300kV. Investigations were also in progress, with high-frequency a.c. superimposed on the d.c. system to simulate the kind of transients that might be experienced in service. He said that in still-air laboratory conditions insulators under high-voltage d.c. tended to attract dust, polluting the surface. But in actual service the insulators were kept clean by the effects of wind and rain.

Alternating Voltages above 220kV

Developments in power transmission at very high alternating voltages were discussed on June 7th, the chairman for the session being Mr. H. L. Melvin (U.S.A.) and the special reporter Mr. F. Cahen (France). Abstracts from Mr. Cahen's report summarising the papers under discussion are reproduced here.

275kV Systems.—The first Japanese 275kV transmission system, as described in the paper by T. Shinbara, is being developed by the Electric Power Development Company.

The 350MW Sakuma power station is being built on the middle reaches of the Tenryu River in the central part of Hokkaido and the output will be transmitted to Tokyo and Nagoya by 275kV overhead lines, 185km and 83km long respectively. Each phase line consists of a single a.c.s.r. conductor of 34mm diameter. The use of a bundle conductor, with its lower corona loss and line reactance was considered, but it was rejected mainly because of doubts about its ability to withstand violent typhoons. The lightning insulation level of the transformers is 1050kV with a reduced level on the neutral side.

330kV Systems.—The Australian 330kV transmission system described in the paper by W. Diesendorf will link the power stations in the Snowy Mountains to the consumer centres in New South Wales and Victoria. By 1959 the first stage, consisting of a 500-mile link between the main load centres, should be in commission. Ultimately, when the system is extended north of Sydney to connect with the large steam power plants on the northern coalfields, the total length of 330kV line is expected to be about 1500 miles. Details of the first 330kV circuit, from T_1/T_2 at the Snowy Mountains hydro stations to Dapto, a distance of 195 miles, are summarised in Table IV. Provision is made for "light" towers on the ice-free part of the route, which includes most of the total length; for those parts of the route where the altitude is between 3000ft and 5200ft above sea level, and where ice and strong winds are experienced, a single-circuit tower of heavier construction is to be used, designed to withstand full breakage of any phase. The conductor cross section of 0·71 square inch equivalent copper was chosen from economic considerations. By dividing this section into twin conductors the corona and radio interference requirements will also be met and the use of a special design of conductor is avoided. All the 330kV transformers will be shell-type water-cooled equipments with 10 per cent reactance and graded insulation, designed for impulse withstand levels of 1300kV full wave, and 1500kV chopped wave.

In the U.S.A. a total of 649 route-miles (1162 circuit-miles) are now in service on the systems of the American Gas and Electric Company (A.G.E.) and the Ohio Valley Electric Corporation, as described in the paper by Messrs. Philip Sporn and W. S. Price. A further 231 miles of similar line are under construction on the A.G.E. system. Interesting details of operating experiences on the system, particularly its lightning and corona performance, emerge from the paper.

Very thorough tests were done on radio-communication disturbances produced during the operation of these lines; these tests concern the measuring instruments, the longitudinal variation of the level of disturbance due to the sag of the conductors, the transverse attenuation, the influence of the voltage (the level varies as the 7th power of the voltage), the influence of bad weather, the ageing of the insulation, and the arrangement of the six conductors on the towers. The first line in operation gave rise to interference levels substantially higher than the figures obtained from experiments based on the

Table IV—*First 330kV Circuit, T1/T2 to Dapto, New South Wales*

	"Light" construction below 3000ft	"Heavy" construction 3000ft to 5200ft
Conductors	Twin bundles: 54/0·117in aluminium and 7/0·117in steel, diameter 1·053in; bundle spacing 15in	
Earth wires	Two 7/0·144in steel	
Insulators, cap and pin	20—10in. × 5¾in	22—10in × 5¾in
Phase spacing	35ft	37ft
Clearance to structure (suspension tower):		
At 30 deg. swing angle	105in	115·5in
At 40 deg. swing angle	84in	92·5in
At 60 deg. swing angle	60in	66in
Normal span	1270ft	1180ft
Approx. weight of suspension tower	5·3 tons	6·2 tons
Approx. weight of towers per mile	25 tons	29·5 tons

Tidd† tests; the reason for this difference is two-fold: leakages out of the impregnating material of the insulating paper of the cables, and superficial scratches caused during stringing. These faults have since been eliminated by reducing impregnation, by increasing the diameter from 40·5mm to 44·5mm and by avoiding all contact with the soil during the stringing of the cable. On the other hand, television does not seem to set a serious problem, owing to the very high frequencies used. Flashovers on insulator chains due to lightning occur much more often than was foreseen theoretically; a full study of this phenomenon is being carried out; it seems that the flashovers occur on the wave front at the beginning of the first microsecond, and therefore they cannot be eliminated either by lowering the earthing resistances of the towers or by using earthing cables.

Sleet melting was necessarily a factor in the selection of conductors for the 330kV systems. Calculations and tests indicate that, for the conductors chosen, currents of 1200A to 1800A are required to remove sleet from the lines in a reasonable length of time. The currents are obtained by applying 132kV to 330kV line sections, 55 to 85 miles in length, short circuited at the remote terminal. A sleet melting current of 1200A at 132kV required a supply of approximately 26,000kW and 275,000kVAr, and 1800A requires 39,000kW and 410,000kVAr. Any 132kV busbar used as a source for melting sleet must be capable of supplying this reactive without excessive voltage drop. Both sleet melting and sleet prevention procedures were successfully applied to the 330kV systems during the winter months of 1954–1955.

330kV operating experience to date has indicated that, in general, the original line designs provide the most economical and efficient solution to the system transmission requirements. These designs will, therefore be used for expansion of the 330kV systems. To obtain experience with bundle conductor construction, which may be necessary in the distant future to provide capability on long line sections at higher voltage, it is planned to install two conductor bundles on a short section of a new line. This procedure will permit a direct comparison of the relative radio interference levels of single and bundle conductor lines, and will also provide design and operating experience with bundle spacers and hardware. Also, on this section the amount of insulation will be slightly increased and a second ground wire installed in an attempt to determine the effect of these parameters on lightning performance.

380kV Systems.—Construction of Finland's first 380kV system was started in 1954 as described in the paper by Messrs. L. Nevanlinna and L. Arponen. In Finland, as in Sweden, generation of electricity is based mainly on water power resources, the undeveloped parts of which are in the north, while the principal consumption centres are in the south. Exploitation of water power in northern Finland began after the second world war and, to-day, a total of about 300MW is transmitted south by two 220kV lines, 500km long. The transmitted power is expected to reach 1500MW, a fivefold increase, within fifteen years. By using 380kV for the third transmission line, a saving of 25 per cent in investment and annual charges is anticipated compared with the corresponding figures for 220kV.

The northern stage, Petäjäskoski-Pikkarala-Alajärvi (380km) of the new line is due to be in service at 220kV this summer. When the southern stage, Alajärvi–Hikiä II is completed two years later, the whole transmission line, 650km long, will be operated at 380kV. The first 380kV line, together with the two existing 220kV lines, will provide a total transmission capacity of about 900MW. Later, a second 380kV line will be added, making the total capacity 1600MW, and it will be possible to increase that by installing series capacitors.

The first 380kV line will be a single-circuit, three-phase line, consisting of twin conductors, 32·85mm diameter, spaced 45cm apart. Connection between the 380kV and 220kV systems will be made by 400/220kV auto-transformers in single-phase units of 75MVA, 125MVA and 140MVA. The tertiary windings of these transformers will be connected to the power station generators and the compensating machines. The lightning insulation level of the transformers is 1650kV. Line compensation is effected by six reactances spaced along the system, providing a total of 370MVAr. At Pikkarala, where the 400MW power stations of the Oulu River will be connected to the 380kV line, a phase-shifting transformer will be installed so that the load sharing between the 220kV and 380kV systems can be varied by 60MW to 90MW. By transferring 90MW to the higher voltage system a saving of 3MW in transmission losses can be achieved.

As explained in the paper by Messrs. G. Boll and H. Roser, the increased power demands in Western Germany within the next few years is expected to outstrip the capacity of the existing 220kV systems linking the Rhine-Ruhr with the south and the Alpine regions with the north. Accordingly, a 380kV transmission system is under construction. The first part of this system is expected to be operating at 380kV next year. For the most part the new network will consist of double-circuit, three-phase lines, having bundles of four square-mounted 21mm diameter conductors. Interconnection with the existing 220kV and 110kV systems will be effected either by 400/230kV auto-transformers, with mesh-connected 30kV tertiary windings, in single-phase units of 66MVA and 33MVA, or by 400/2 × 115/30kV transformers in single-phase units of 33MVA. The lightning insulation level is 1450kV. All transformers are fitted with on-load tap-changers and the operating voltage of the system will be between 360kV and 420kV. Line capacitance is compensated, on the basis of 65MVAr per 100km, by means of three-phase, 50MVA reactors connected in the system. The short-circuit power may reach 8000MVA in the first stage of the project and 12,000MVA to 14,000MVA later.

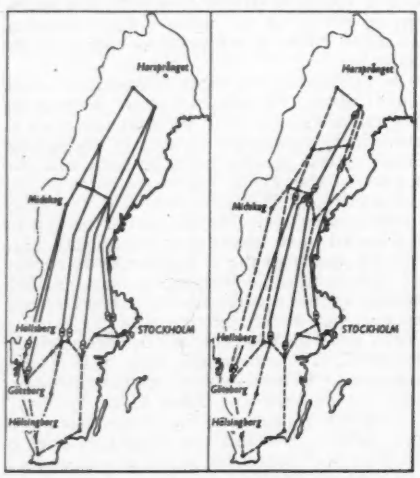
The 400kV transmission line linking Kuibyshev and Moscow, as described in the paper by Mr. A. A. Gogolin and his associates, constitutes the first stage in the development of a Russian 400kV power system. This single-circuit, three-phase, 815km line, which was first described in the 1952 C.I.G.R.E. meeting, has recently been taken into service at 400kV. It is equipped with bundles of three conductors, 30·2mm diameter, arranged on an equilateral triangle of 40cm side. It will be duplicated by a second line, now under erection, 890km long, parallel to the first one with three intermediate paralleling stations. The lightning insulation level of the transformers, both at the sending and receiving ends of the line, is equal to 1500kV. The receiving-end station lowers the voltage from 400kV to 110kV. The 110kV busbars are also linked to the 220kV system of the Moscow region by two groups of transformers 400/115kV, single-phase units of 90MVA, with an 11kV tertiary winding, with separate on-load tap-changers mounted on the 115kV side. The higher operation voltage of the system is 420kV. The system is compensated by shunt

† The 500kV Tidd testing station was built to obtain corona loss and radio interference information at various voltages on various conductor arrangements under all-the-year-round weather conditions.

reactances mounted at both ends and in the middle of the system and connected directly to the 400kV line, by series condensers connected to the middle of the system and by synchronous condensers each of 75MVAr, connected to the tertiary winding of each of the receiving-end transformers. The breaking capacity of the switches is equal to 10,000MVA and in the future the use of a 15,000MVA switch is proposed. The capacity of the power system, with its two parallel circuits, is equal to 1150MW.

The first French 380kV system, as described in the paper by Mr. A. Louvet and his associates, is expected to be in operation next year. It consists of a single-circuit three-phase line 516km long, in three sections, and will be derived from the conversion of a double-circuit, three-phase line at present working at 220kV. The new line will have twin conductors, 26·4mm diameter, 40cm apart. It will be connected to the existing 225kV systems at both terminal stations and at two intermediate transformer stations by four groups of 380/225kV auto-transformers, with 11kV mesh-connected tertiary windings, each transformer consisting of three single-phase, 100MVA units. The lightning insulation level is 1450kV. The operating voltage is between 380kV and 420kV and there is provision for the auto-transformers to be equipped with on-load tap-changers in the future. Compensation for line capacitance is provided by shunt reactors connected to the tertiary windings, each transformer station having two reactors of 48MVAr each, making a total of 384MVAr. The capacity of the line will be 500MW initially, to be increased later when the line is duplicated.

Voltages Higher than 380kV.—As explained in the paper by Messrs. G. Jancke and S. Lalander, when the Swedish 400kV system was



Full lines 500kV. Dotted lines 400kV. Full lines 650kV. Dotted lines 400kV.

Fig. 1—Future Swedish bulk transmission systems
(Left): 500kV system carrying 45×10^9kWh annually from north to south
(Right): 650kV system, carrying, annually, 45×10^9kWh from north to south on 650kV and 400kV lines

planned the water power in the country suitable for exploitation was assessed at 40×10^9kWh/year. It was estimated that it would be necessary to transmit 16 to 18×10^9kWh/year over the 400kV system and 3000MW to 3400MW from North to South Sweden. For this purpose six 400kV twin conductor lines (without series capacitors) would be required in addition to the six existing 220kV lines.

The first stage in the construction of the 400kV system was completed in 1952, when the Harsprånget-Midskog-Hallsberg line was placed in service under the full voltage. In the autumn of this year the first line will be supplemented by two further 400kV lines running from north to south, and in addition the 400kV system is being extended to southernmost Sweden by a Hallsberg-Göteborg-Hälsingborg line (see Fig. 1). The total length of the 400kV lines amounts to 2710km and the maximum transmission distance from north to south is 1335km. The 400kV transformer output connected-up amounts to 4365MVA. The loading capacity of the system has been considerably increased by means of 400kV series capacitors totalling 310MVAr. To enable the desired smooth voltage regulation to be obtained, three hydrogen-cooled synchronous condensers, each for 75MVA, have been installed in the most important receiving stations, together with 1000MVA reactors. Furthermore,

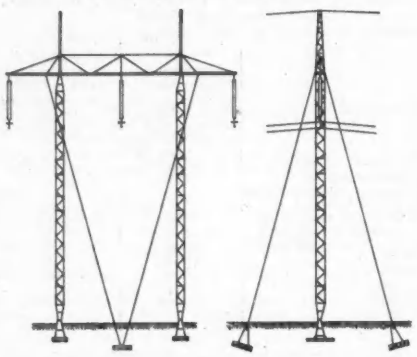


Fig. 2—Proposed form of tower for 400kV, 500kV or 650kV lines in Sweden

to improve stability, the transformers and generators connected to the system have been designed with extra-low reactances (auto-connected transformers 400/220kV and 400/130kV).

According to measurements made on network analysers, 2000MW can be transmitted over the three parallel-connected 400kV lines with full transient stability under all line faults when the line reactances are compensated up to 40 per cent by series capacitors. To this must be added the 1000MW loading capacity of the six parallel-connected 220kV lines. It is anticipated that the total demand for power transmission will not have risen to 3000MW before the year 1960; accordingly it has not yet been decided to construct a fourth 400kV line from North to South Sweden.

The demand for power transmission over the Swedish trunk line system is now expected to reach very much higher figures than was the case ten years ago when the 400kV system, now in course of construction, was first planned. In these circumstances a further investigation of the system voltage to be adopted in the future is called for. Three main alternatives are being studied: the retention of 400kV, a change to 500kV over the greater part of the system and the superposition of a 650kV net on the 400kV distribution network in the north and south. 500kV has been selected as the highest possible voltage for the present 400kV line design, and 650kV is regarded as the highest conceivable operating voltage.

For the lengths of line of about 550km which are usual in the Swedish system, the insulation level for the new 400kV installations can be limited to 1300kV. At 500kV a level of 1600kV is necessary and at 650kV the level is about 2000kV. By employing heavy multiple conductors it is believed that corona and radio interference can be kept within permissible limits. It would appear that the short circuit power is not likely to exceed 18,000MVA, which should not give rise to insuperable difficulties for apparatus designers.

To permit an economic comparison, new line designs for 500kV and 650kV have been prepared. It appears possible to manufacture the necessary auto-connected 500/400kV and 650/400kV transformers in single-phase units up to 400MVA and 300MVA, respectively. The optimum loads on the lines have been assessed at about 800MW at 400kV, 1000MW at 500kV, and 1700MW at 650kV. A preliminary comparison for a schematic network shows a slight reduction in the costs when changing from 400kV to 500kV and a somewhat greater reduction when adopting 650kV. The detailed investigations relating to the future Swedish power system have not been completed, but preliminary results tend to show that the costs at 500kV and 650kV will be about the same.

The specific transmission costs (the total annual costs per kW transmitted) for the various alternatives studied are tabulated herewith. An outline of the proposed form of tower is shown in Fig. 2.

Voltage	Type of conductor	Optimum output transmitted	Optimum series compensation	Specific transmission costs
kV	mm^2 ACSR conductor	MW	Per cent	Crs./kW, 100km year
400	2×593	600	38	3·61
400	3×593	780	47	3·36
400	2×908	780	54	3·35
500	3×593	1030	43	3·26
600	4×593	1720	70	3·04

On the basis of the present estimate of the country's water power resources available for exploitation and a forecast of the energy consumption's geographical distribution in the future, alternative transmission line systems have been worked out for the whole of the Swedish power transmission (networks for 400kV and higher voltages). In the first place the calculations are based on a stage at which 70×10^9kWh water power has been developed. Fig. 1 illustrates the network sketched out here with 500kV and 650kV as the main transmission voltage. In both cases 400kV has been retained unchanged as the primary distribution voltage in South Sweden. The reason for this is found in the heavy costs for reconstruction which would be entailed by raising the voltage in the five existing 400kV transformer stations and the difficulty of direct transformation from 500kV or 650kV to 130kV. In the 500kV alternative the other parts of the system have been designed for 500kV, partly by reconstructing the existing 400kV lines. 500kV will thus also be the primary distribution voltage in the north. On the other hand, this has not been considered possible in the 650kV alternative, owing to the difficulty of obtaining reliable 650kV circuit breakers, amongst other reasons. The 650kV network would, therefore, consist in principle of a line network superimposed on the 400kV networks in the north and south.

The possibilities of high voltage d.c. transmission are also being studied, but this work has not yet reached a sufficiently advanced state to allow any conclusions to be made.

Discussion

Opening the discussion of the papers dealing with e.h.v. transmission, Mr. P. L. Bellaschi (U.S.A.) said that perhaps too much attention was being given to higher nominal voltages, whereas more might be done by basic engineering design towards the upgrading of existing systems. American work had shown, for example, that single a.c.s.r. conductors of 1·382in diameter were suitable for 300kV or higher, and 1·602in diameter for 360kV. Bundle conductors, $2\times1\cdot382$in diameter, could be used for 400kV. He quoted data justifying a similar two-stage reduction in breakdown impulse level which could lead to upgrading of existing equipment without any ill-effects.

Dr. H. Roser (Germany) referred to the R.W.E. 380kV system which was due to be in operation next year. The problem of ensuring proper load sharing between the 380kV and 220kV systems operating in parallel was being solved by the use of a phase-shifting transformer in the 380kV line.

Dr. I. Herlitz (Sweden) referred to the topic of e.h.v. standardisation. Further evidence of the desirability for standardising was contained in the revelation that Sweden had found that only very small gains were to be derived from increases of voltage up to 500kV or 650kV, as described in the paper by Jancke and Lalander. He concluded that an increase in voltage was justified only if the jump was substantial. Similar thoughts were expressed by Mr. Jancke, who stated that the situation was becoming confused with the proposal to develop three new systems, 330kV, 275kV and 220kV in Australia.

Mr. R. S. Arnot (South Africa) referred to the new 220kV, 320-mile line linking the Belgian Congo with Northern Rhodesia. It was possible that in the future this circuit might be linked with the Kariba gorge project at 330kV. He was interested in single-phase auto-reclosing and he asked whether its use was limited to about 150 miles at 330kV, as might be inferred from one of the papers under discussion.

Mr. Lebedev (U.S.S.R.) described some tests carried out to establish the over-voltage characteristics of the 400kV line from Moscow to Kuibyshev. A switching station was set up at one end of the line and switching surges were measured on oscillographs at the other end. With reactors connected the over-voltage was of the order of twice the phase voltage ; without reactors the over-voltage was about 2·5 times the phase voltage.

Discussing radio interference, Mr. W Casson (Great Britain) referred to the paper by Messrs. Sporn and Price, in which it was stated that the radio interference level was worse with an asymmetrical double-circuit line than with a symmetrical arrangement. He said that in Great Britain the original intention had been to use a symmetrical layout for the 275kV lines, but a change had been made to an asymmetrical arrangement to reduce electrostatic induction effects on equipment under the lines ; a small reduction in reactance was also achieved thereby.

Mr. R. E. Martin (Great Britain) discussed other aspects of radio interference. He commented on the fact that most of the work mentioned in the papers related to measurements at 1 Mc/s ; a certain amount had been done at 20 Mc/s to 30 Mc/s. But there was urgent need for measurements at frequencies up to 200 Mc/s. Interference in that waveband had given rise to complaints in Great Britain. In the v.h.f. band radio interference increased by about 10 to 15 per cent in dry weather, whereas the opposite was the case at lower frequencies. There was a need for testing insulators for interference over a wide range of frequencies up to the v.h.f. band.

Dr. G. Lesch (Germany) referred to some tests made at Mannheim on a 380kV line, which indicated that bundle conductors were preferable to single conductors because they gave rise to reduced radio interference and because they gave a better voltage distribution on the insulator string. Mr. R. Pelissier (France) confirmed the lower radio interference level of bundle conductors.

Reverting to the question of single-phase auto-reclosing, Mr. Burgsdorf (U.S.S.R.) asserted that the practice was very effective. On the Moscow-Kuibyshev line a de-ionising time of 0·6 second, with a capacitance current of about 60A, had been measured. He believed that single-phase auto-reclosing was feasible up to 480km on a 400kV line, about 70 per cent of the line capacitance being compensated by reactors.

Antibiotic Production Plant

On a site at Sandwich a plant to manufacture one of the new antibiotics, Terramycin, has been built by Pfizer Ltd. The buildings occupy an area of 120,000 *square feet and produce pure crystals of Terramycin hydrochloride, which are packed in containers and delivered to a processing factory at Folkestone. Here the antibiotic is incorporated in various preparations for medical and veterinary purposes.*

SIR ALEXANDER FLEMING'S discovery of penicillin and the endeavours made to produce it on a mass scale have led to the evolution of a new industry. This is concerned with the conquest of the microscopic world and the expansion of biochemical engineering to develop plant which would perform micro laboratory techniques on a commercial basis. This industrial development took place mainly in the U.S.A., where research succeeded in discovering strains of penicillin having greatly increased yields.

The establishment of large-scale production of penicillin (effective against gram-positive bacteria), was followed by the appearance of streptomycin, an antibiotic active against gram-negative organisms. Then came the first of the so-called broad spectrum antibiotics, chloramphemicol, which emerged from a sample of mud. Later tests on other samples of moulds have given us Terramycin, and, more latterly, Tetracyn, which are effective against both gram-positive and gram-negative disease-producing organisms, and also against certain parasites and viruses.

The Pfizer Company of America is one of those engaged in the production of antibiotics and was responsible for the deep fermentation method of manufacture. It was in the research laboratories of the company that the new antibiotic Terramycin was discovered after making millions of tests on more than a hundred thousand soil samples collected from all parts of the world. The mould that was eventually found was named Streptomyces rimosus.

It is over three years since Pfizer, Ltd., was established in the United Kingdom, when a factory was built at Folkestone, where the material, imported in bulk, was prepared for marketing. Since then a decision was made to manufacture Terramycin in England, and a site was acquired at Sandwich, which is fairly close to Folkestone and which satisfied other requirements. These were : availability of suitable labour, clean air, proximity to a navigable river, and room for expansion. The site is about 80 acres in extent and the buildings have an area of 120,000 square feet and the construction of the factory, which was completed in nine months, entailed reconstruction and adaptation of existing buildings and the erection of new buildings to house the fermentation plant and other process equipment. For this work about 300 tons of structural steel was used and 10,600 tons of concrete. The completed factory is illustrated in Fig. 2.

Manufacturing Process

The fermentation plant for the production of broad spectrum antibiotics has been designed to supply the requirements of Great Britain and the countries within the sterling area and represents not only a saving in dollars but a valuable export. Deep fermentation as a method of producing antibiotics was introduced by the parent company in America during the war to supersede the limited laboratory system and to make the large-scale manufacture of penicillin possible.

The fermentation principles used in the making of antibiotics are essentially the same as those of brewing, but the practical problems involved are not comparable. For in dealing with organisms which can rapidly increase a million fold in a few hours it is necessary to grow only one kind of organism in the fermenter and to sterilise thousands of gallons of medium.

To commence the whole operation an initial or master culture is essential, and for this purpose master cultures of the mould were flown over from the company's laboratories in America. These initial cultures and cultures grown from them are now stored in the sterile area at Sandwich and every precaution taken to ensure that no contaminating organisms can be introduced and so ruin the whole process. Part of the sterilising equipment of the spore laboratory is shown in Fig. 5. The master culture spores are stored in a dried state on sand, contained in ampoules, and kept at a constant temperature in a refrigerator.

To start the process, spores from the master culture are propagated, both on solid and in liquid media, and a vegetative inoculum is produced. The vegetative growth is further increased through several stages in inoculum development tanks, the increase being measured in terms of hundreds of millions of times above the original withdrawal of the organism from the master culture.

While the liquid culture is being started parallel operations take place in the building allocated for the preparation of the medium. Various cereal products form the basis of this fermentation medium, which has to be a well-balanced food containing carbohydrates, proteins and accessory food factors, such as mineral salts and vitamins. The bagged raw materials are emptied into a battery of 2000-gallon capacity mixing tanks, which are supplied with hot and cold water and steam, and are fitted with stainless steel gate agitators driven by electric motors. After mixing with water the medium is heated and pumped to the fermenters, which are housed in a separate building. The height of the building, which can be seen in our illustration of the plant, gives a rough idea of the size of the fermenters. Live steam is used for sterilising the medium and, after cooling, the inoculum is added and the mould begins to grow. This growth process generates a considerable quantity of heat and the temperature in the vessel is maintained constant by means of stainless steel water-cooled coils, automatically controlled.

Since the mould must " breathe " in order to live, it is necessary to feed the fermenters with large quantities of air which has been rendered sterile by filtration. Foam which forms in the vessels from time to time is controlled by the addition of a suitable defoaming agent.

After a period lasting several days, to allow Terramycin production to reach a maximum, the broth, consisting of highly diluted Terramycin,

Fig. 1—Terramycin refining plant for final crystallisation

Fig. 2—Terramycin manufacturing plant at Sandwich

Fig. 3—Glass-lined and jacketed reaction vessels

Fig. 4—Air compressors for supplying sterile air

mould and the remainder of the medium, is ready for delivery to the clarification area. It is pumped from the fermenter to holding tanks, equipped with agitators, where it is treated with chemicals to assist filtration, and from these it passes to a Dorr-Oliver continuous filter, where a vacuum created in the filter drum draws the liquid through to leave unwanted solids, mould and nutrients, on the outer surface. These are cut off continuously and removed on an endless belt conveyor and are being increasingly used for animal feedstuffs. The clear filtrate from the Dorr-Oliver machine flows to a holding tank, where chemicals are added to aid the precipitation out of solution of an intermediate salt of the antibiotic. This is in the form of a slurry and by means of steam-driven pumps is fed into a pressure platen filter press, where the salt is collected on the frames and dropped into stainless steel troughs. From these the salt is transferred to stainless steel trays, which are loaded on to racks, the racks then being wheeled into hot air drying chambers. At this stage the intermediate salt is a solid mass and is then milled to a very fine powder before being stored in drums prior to refining.

In the refining area the intermediate Terramycin-salt is converted into its medically usable form, namely, Terramycin hydrochloride, which is a yellow crystalline powder. Solvent is pumped into glass-lined, jacketed reaction vessels, some of which can be seen in Fig. 3, fitted with anchor pattern agitators, and then a weighed amount of intermediate salt is stirred in. After this, decolorising agents are added and the resulting liquid is pumped through a platen frame filter where insoluble matter is removed and a clear solution of salt passes on to vacuum tanks fitted with steam ejectors. Here, a higher concentration of intermediate salt is effected and the concentrated solution passes to a glass-lined crystallising vessel, where first stage Terramycin hydrochloride is precipitated. This passes through the bottom of the vessel to a centrifuge, in which the hydrochloride is separated from the mother liquors. The resulting hydrochloride is now dissolved, filtered clear and recrystallised as the pure salt. After spinning and washing, the pure crystals of Terramycin hydrochloride are dried in a vacuum oven, (Fig. 1) and are then packed into containers, ready for dispatch to the Folkestone factory.

Throughout the process samples are taken and tests made so that the material is carefully checked at each stage to ensure the quality and potency of the product and also the sterility is maintained.

Factory Services

Steam for the various services is provided at 150 lb per square inch gauge by two Marshall horizontal economic boilers which burn oil fuel under forced draught and have an evaporation rate of 20,000 lb per hour. The burners and the fuel oil pumping and heating unit were manufactured by British Combustion Equipment, Ltd., and the fuel, of 3500 second Redwood scale, is stored in two 35,000-gallon tanks. There is also a Cochran Economic Sinuflo induced draught boiler rated at 9100 lb per hour and the feed water, which is softened by the William Boby hot lime-soda-treatment, is supplied to the boilers by Weir feed pumps and regulated by Ronald Trist thermo-feed automatic control.

In the pump house there is a total of twelve pumps, four of 500 gallons per minute circulate the warm water from the hot well to the cooling tower, and another four pumps of similar capacity recirculate cold water around the plant. Water is supplied by the local water board and two pumps rated at 180 gallons per minute deliver the water to the 150,000-gallon header tank, while two 150-gallon per minute pumps circulate the water around the system. The timber cooling tower, supplied by Peter Brotherhood, Ltd., is in four sections, each of which is supplied with air by a 13ft diameter forced draught fan. Broom and Wade, Ltd., has manufactured the air compressors and all are cooled with normal service cooling water.

One compressor, which delivers 200 cubic feet of air at 100 lb per square inch, meets the general service requirements of the plant, a battery of compressors providing the fermentation air, for which there are two receivers, while there is

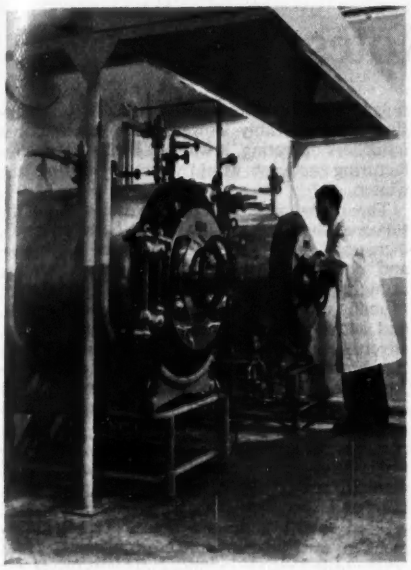


Fig. 5—Spore laboratory sterilising equipment

one receiver for general service air. All the compressors, some of which can be seen in Fig. 4, are mounted on 8in cork anti-vibration mountings. Air for fermentation first passes through a water cooled heat exchanger and filters before it is used. The refrigeration plant consists of two ammonia compressors, provided by J. and E. Hall, Ltd., having a total capacity of 360,000 B.Th.U. per hour, and a solution of Ethylene Glycol is circulated as a coolant. All distribution piping is carried overhead on trestles and other ancillary equipment includes solvent and corrosive liquor storage tank farms, and a solvent recovery plant.

Electrical power at 11,000V is supplied by the South Eastern Electricity Board to a sub-station equipped with Reyrolle H.T. equipment, and then to five 500kVA English Electric transformers and an L.T. room fitted with "Superform" switch fuse gear supplied by the English Electric Company, Ltd. Distribution throughout the plant is at 415V through underground fibre ducts, and there is a distribution board in each department. Allen West starters are standard, while motors up to 20 h.p. are by Lancashire Dynamo and Crypto, Ltd., and those over 20 h.p. have been provided by Laurence Scott and Electromotors, Ltd. Flameproof motors have been supplied by Crompton Parkinson Ltd.

Processing Plant

As already mentioned, Pfizer, Ltd., has been operating a factory at Folkestone,. This is a pharmaceutical processing plant where the drug is incorporated into the various preparations required for medical and veterinary use. Hitherto, supplies have been imported, but with the completion of the new works, supplies of Terramycin are now received for processing from Sandwich. On arrival Terramycin is blended with additives to stabilise the product for injection purposes and is also stabilised to the required value on the pH scale. This refining operation is shown in Fig. 1.

All the vials and bottles used for containing the antibiotic are carefully washed and sterilised in a department equipped for that purpose. There is a single jet washing machine capable of dealing with 2500 bottles per hour, and a multi-jet unit which handles vials at the rate of 8000 per hour. After washing, these containers are placed on stainless steel trays, the trays are loaded on to a trolley which is pushed into a double-ended dry heat electric steriliser set in a wall enclosing the sterile area. When the operation is complete the trolley is moved through the door at the other end of the steriliser into the sterile cooling room in the sterile area, which is under pressure in order to prevent any ingress of atmospheric air. Air for the sterile area is supplied by a "Birlec" gas-fired drying unit, similar to that installed at the Sandwich factory, which dries the make-up air to 20 per cent relative humidity. This air is cooled, and together with recirculated air, which has passed through a cyclone and paper filters, passes through electrostatic precipitators, paper filters and glass wool before being circulated to the sterile area. Washed rubber stoppers and clothing pass into the sterile area via a steam autoclave. All filling of bottles and vials is carried out under strictly sterile conditions, as indicated in Fig. 6, before passing out on a moving band conveyor to other departments for capping and labelling ready for despatch.

In the tablet manufacturing department a binding agent and a disintegrant, both of which have been dried, are mixed with Terramycin and the powder mixture made into slugs. These are broken down into granules in a rotary granulator and then pass through a sifter to ensure that the size of the granule is uniform. The granules are fed into a rotary tablet forming machine and the resulting tablets pass to a battery of pans which apply various finishing coats to the tablets. In the first pan the tablets are given a coat of shellac varnish. At the second stage they are built up with a gelatine coating followed by a white sugar coating. Then follows a coloured sugar coating, the process being completed by the application of a wax polish. A careful inspection is then made by using a machine which ensures that both surfaces of the tablet are viewed.

Among other operations carried out at this plant are the production of sterile and non-sterile liquid preparations, and of non-sterile powder preparations. In addition, capsule filling and the preparation of ointments take place. The machinery necessary for this includes a number of units which have been designed by the plant's own engineers to deal with the stages of production which are peculiar to this particular product.

All the steam, 80 per cent of which is returned as condensate, required for the various services is provided by a Paxman Economic boiler fitted with two Clyde automatic oil burners supplied from a Clyde oil fuel unit. The boiler has a working pressure of 150 lb per square inch, an evaporation rate of 7000 lb per hour, and is supplied with feed water, softened by the hot lime soda process, by two Weir pumps. Two service compressors supply air at 50 lb per square inch and there is a Nash Hytor vacuum pump, while the process water, which is taken from local supplies, is softened and distilled in three distilling units, each having a capacity of 50 gallons per hour.

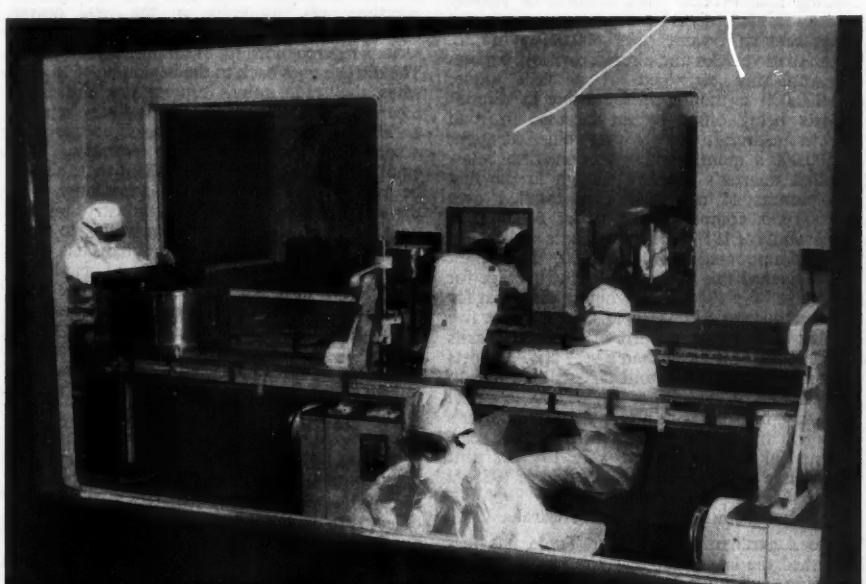


Fig. 6—Preparation and filling of vials in sterile area

House Construction on Expansive Soils

BY OUR SOUTH AFRICAN CORRESPONDENT

A NEW method of construction developed by the South African National Building Research Institute to overcome cracking due to expansive soils is being tried out on a private house now in course of erection near Pretoria. Instead of the normal foundations, the house is built in three sections, each of which rests on three small concrete pads. The walls are made of reinforced brickwork. The main cause of cracking of buildings on expansive soils is the uneven "heaving" of the soil after the house is built. In larger structures this can be overcome by founding the building on piles anchored below the level of soil expansion, but this method is often too expensive for house construction. Using the principle that three points will always remain in one plane, no matter how they move relative to each other, the S.A.N.B.R.I. has designed and tested a number of experimental structures founded on three-point foundations. Two of the foundation pads are situated at the corners at each end of one wall, while the third is placed at the middle of the opposite wall, the remainder of the building being completely free of the ground. The walls, which are reinforced with steel rods to form deep beams, carry the weight of the floors, roof, internal partitions and contents, to the foundation pads. The opportunity to try out the method in practice occurred recently when the Institute was approached by a private individual who had inadvertently purchased a building plot where expansive soil has been encountered. Working in co-operation with the architect who drew up the basic plans for the house, the Institute has helped in developing a structural design which should be unaffected by any soil movement that may take place. The new method is more expensive than brick and mortar construction on conventional foundations, but in the long run will undoubtedly be cheaper than attempting to repair the serious cracks which would appear and become progressively worse in an ordinary house built on this site. Heaving of this kind can be considerable and continues over a number of years. In one example observed by the Institute in the Orange Free State, the ground at one section has risen 8¼in over the past three years, and there still appears to be no reduction in the rate at which the soil is heaving. Data for the design of houses of this kind will be made available in due course to those confronted with similar problems.

Industrial and Labour Notes

The Economic Situation

In the latest issue of its *Bulletin for Industry*, the Treasury says that the economic indications for 1956 suggest so far that, over the past twelve months, there have been "changes in the right direction" in the pattern of demand. The volume of exports has continued to rise, and even when allowance is made for last year's dock strike, was 5 per cent higher in the first five months of 1956 than in the comparable period last year. But, the Treasury adds, German exports in the first four months of 1956 were 16½ per cent higher than a year earlier, whereas the United Kingdom's were only 6 per cent higher. The gold and dollar reserves, in the first five months of this year, have recovered about two-fifths of last year's losses; but, the Treasury comments, since the first half of the year is normally better than the second, this is only moderately encouraging.

The Treasury goes on to say that the demand for plant and machinery for the home market has risen, and that the volume of retail sales appears in the first four months of 1956 to have been slightly lower than a year ago. But, the observation is then made, the improvement which has shown itself so far will not go far enough or fast enough if there is any further sizeable rise in money incomes. If further increases in total wages, dividends, and profits are no more than in line with increases in the country's output, there is a reasonable prospect that the recovery so far made will be consolidated and the rise in prices will be checked. The *Bulletin* points out that incomes in the last year have risen considerably faster than output. At the end of April wage rates were 8 per cent higher than a year earlier. The figures for profits of industrial companies declared in the first quarter of this year relate to a period ending on average some months earlier; they were 11½ per cent higher than a year before. Increases of this kind, the Treasury says, are incompatible with price stability; and, mainly because total incomes in the country have risen faster than total output, retail prices in April were 7½ per cent higher than a year earlier.

About the pattern of production, the *Bulletin* records that the output of capital goods has risen and the production of consumer goods has fallen. In January and February, the production of plant and machinery was estimated to have been 6½ per cent higher than a year earlier. Steel output has been running some 7 per cent higher than a year ago; coal output is up a little, strike losses in the industry this year having been only one-third as big as in 1955. The total index of industrial production in the first four months of 1956 was about 1 per cent higher than a year earlier, but, the Treasury observes, "seasonally corrected" it was 1 per cent lower than in the second half of last year.

Coal

Last week, the National Coal Board announced that "unless something quite unexpected and exceptional" happened, it would not increase pithead coal prices during the next twelve months. The Board drew attention to its recent statement (summarised in these notes on June 1st.), explaining that the latest coal price increases were intended to cover the full costs in 1956 and 1957, and also to recover part of the accumulated deficit.

The Coal Board's statistical statement, which was also issued last week, shows that in the first quarter of this year there was an estimated surplus of £6,089,059. During the quarter, the quantity of coal "disposable commercially" was 50,935,659 tons, the proceeds from the sale of coal being £201,874,721. The total costs of production were £192,259,662, so that the colliery profit before charging interest was £9,615,059. Profit on opencast coal working in the first quarter has been estimated at £1,800,000, and the profits of the Board's ancillary undertakings are put at £1,119,000. The Board's total profit for the quarter was thus £12,534,059 Provision for taxation and other items required £345,000, and the amount of interest payable to the Minister of Fuel and Power was £6,100,000. The estimated loss on imported coal during the quarter was £6,100,000, but the Board's statement shows that that loss has been met by an appropriation from the proceeds of the sale of British coal. It is recalled in the statement that the general increase in coal prices which was made in July, 1955, was "partly intended to recoup the loss on imported coal."

Overseas Trade

The Board of Trade's report on the United Kingdom's export and import business in May says that the trend shown in the earlier months of this year continued. The value of imports, at £329,100,000, was virtually unchanged compared with the two preceding months. So far this year, imports have been about 1 per cent above the monthly average for 1955. Exports of United Kingdom goods established a new record value of £283,800,000 in May, which was £12,500,000 above the high figure achieved in March. There were twenty-six working days in May, as there were in March. The May export figures included two special items, namely, the value of the liner "Empress of Britain," which was recently delivered to Canada, and a second instalment, exceeding £2,500,000, of silver bullion repayments to the U.S.A. But without these items, the Board of Trade says, the May figure would have exceeded that for March. With re-exports in May valued at £13,500,000, the visible trade deficit declined to £31,900,000. So far this year, the deficit has averaged £51,000,000 a month, which is £21,000,000 below the monthly average for last year.

The Board of Trade goes on to say that the increase in total exports in May was predominantly in trade with the non-sterling countries, particularly the dollar area. About the commodity pattern of trade, it is stated that exports in most divisions were higher in May than in the earlier months of the year. Exports of engineering products reached a figure exceeding £119,000,000. If April and May are taken together, engineering exports averaged over £112,000,000 a month, or 8 per cent more than the average for the first quarter. Exports of ships and boats more than doubled, exports of electrical machinery and apparatus were 6½ per cent above the first quarter's average, and exports of machinery other than electrical were 4½ per cent higher than in the first quarter. Many kinds of machinery were included in this rise, while markets taking more included India, Canada and France. Big exports of railway vehicles in May raised the April-May average by 9 per cent to a value of £4,000,000 a month. In the road vehicles and aircraft division, exports in April-May remained at a little under £33,000,000 a month, a reduction in aircraft exports being offset by an increase in road vehicles. Aircraft exports were valued at about £5,500,000 a month, which was one-fifth below the first quarter's average, though in the first five months of this year they totalled over £32,000,000, compared with under £40,000,000 in the whole of 1955. Exports of cars and chassis in May amounted to £10,500,000; the highest figure reached this year, making the average for April and May 10½ per cent higher than that for the first quarter. Nevertheless, in the first five months of this year, exports of cars and chassis were 15½ per cent lower than a year ago. Exports of commercial vehicles and chassis continue to be satisfactory, averaging £8,500,000 in April and May, or 5 per cent above the first quarter's average. In the first five months of this year, commercial vehicle exports were 13½ per cent higher than in the comparable period of 1955.

Manufacturing Activity in Australia

The Australian Minister for Trade has just published the latest half-yearly report on manufacturing activity. It surveys the six-month period ended April 30th last, during which time, it is stated, manufacturing activity was the highest in Australian history. But the report says also that in recent months the rate of expansion has noticeably slowed, and with seasonal influences operating, it was not likely that manufacturing activity would increase during the winter.

The report indicates that in the six months surveyed the production of most basic materials increased, and that the majority of machinery and equipment manufacturers were operating at higher levels. On the other hand, the output of many durable consumer goods tended to fall, and activity in the motor vehicle industry was adversely affected by the sales tax increases of last March. According to a statement by the Australian Minister for Trade, manufacturing activity is relatively higher in Victoria and South Australia than in the other states. Under the pressure of keen competition, many manufacturers have been compelled to absorb increased material and labour costs without price rises. Increased productivity, it is observed, has assisted this. In the six-month period, investment in Australian manufacturing industry was concentrated mainly in those industries producing basic materials and equipment, and to that development overseas companies were making a substantial contribution in the form of technical and financial assistance. Although manufacturing industry generally was not short of finance for current activity on expansion, credit conditions were becoming tighter and, in some instances, were affecting operations.

Shipbuilding Workers' Hours

Last Monday, the Shipbuilding Employers' Federation met representatives of the Confederation of Shipbuilding and Engineering Unions to discuss claims for a shorter working week and for increased holiday pay. After the meeting, it was announced that the employers had rejected the claims. The unions had asked for a forty-hour week, maintaining that the reduction from forty-four hours could be achieved by increasing productivity. In the last inquiry made by the Ministry of Labour into working hours, however, it was found that the average weekly hours worked in the shipyards last October were forty-nine, which included five hours' overtime.

Steel Industry Dispute

A wage dispute involving maintenance men in the steel industry has led to an overtime ban at some plants and to strikes of maintenance workers at others. The effect of the ban on overtime was noticeable in the steel output figures for May, and will undoubtedly show more serious repercussions on this month's production. The dispute goes back to the beginning of March, when the trade unions representing the maintenance craftsmen in the steel industry rejected an offer of the same wage increase as had been accepted by the production workers. The employers have proposed that the dispute should be referred to arbitration in accordance with the usual practice of the steel industry, but the unions concerned have not been willing to agree to that course. The overtime ban has been operating since the end of April, and, as already stated, has now led to strikes at some steel works. At the time of going to press it has been stated that the union leaders concerned would meet yesterday (Thursday). They are reported to favour a joint inquiry into wages in the steel industry.

Work Study

This week the British Productivity Council (21, Tothill Street, London, S.W.1) has published a pamphlet entitled *Why Not Work Study?* Its object is to explain what work study is, how it is applied, and how "snags" sometimes associated with its introduction can be avoided. Some appendices to the pamphlet deal briefly with the available literature, instructional films, training facilities and the work of the British Productivity Council's work study unit.

T.I.A. Feed Water Treatment

ON June 21st we attended a celebration to commemorate the first 1,000,000km run without major overhaul by a French locomotive which throughout had been subjected to the method of boiler water treatment and management known as the "Traitement Interne Integral Armand des Eaux d'Alimentation des Chaudières," or "T.I.A.," after its inventor, Monsieur Armand, the present chairman of the S.N.C.F.

The meeting, which was held at Nice, was attended by many French and foreign railway officials. After an introductory speech by Monsieur Sauvajol, chairman of the S.N.C.F. Mediterranian Region, there was shown a documentary film illustrating the troubles caused by untreated feed water and demonstrating the application of T.I.A. This was followed by a technical exposé given by Monsieur Gintrac, head of the water treatment section in the Equipment and Traction Department of the French railways. Afterwards the delegates were able to see in the Nice depot the "millionaire" locomotive and two other engines of only slightly lower mileage, all of the type "141 R," and built in 1946 by the American Locomotive Company, of Schenectady. Inspection of the boilers, which have steel fireboxes and tubes, revealed their remarkable, almost "as new" condition, and the complete absence of any scale deposits or signs of corrosion. In his speech at the luncheon which followed, Monsieur Armand referred to the history of the treatment and paid tribute to the engineers and technicians whose collaboration had made this success possible.

The development of T.I.A., which has since been introduced in many countries, including Great Britain, goes back to a number of technical studies, made by the Société National des Chemins de Fer Français since its establishment in 1938. These problems centred on the possibility of reducing coal consumption, then costing some 2000 million francs a year, and on questions of boiler maintenance, in order to save maintenance costs and increase the efficiency and availability of the engines, thus enabling the number of locomotives to be reduced.

The seriousness of the problem caused by untreated feed water is illustrated by the fact that in a locomotive, in which evaporation may reach over 200 litres per kilometre, scale can be formed at the rate of 10-20 grammes per minute. Beside the loss in heat transfer efficiency due to the layer of scale, the temperature of the metal of the firebox may increase from about 230 deg. Cent. to 600 deg. Cent., causing buckling and cracking of plates and fire tubes, and overstraining of the stay bolts, in addition to which there are the effects of corrosion. In spite of removing as much scale as possible by pressure-hosing and cleaning out the boiler every 1000-2000km, a costly and time-consuming overhaul becomes necessary after approximately every 70,000km, with a complete rebuilding of the boiler after 250,000km.

While preliminary water softening had been used by the former French railway companies in particularly bad districts, this practice, as well as the application of boiler compounds, had not succeeded in entirely eliminating the encrusting salts and corrosiveness from the feed water.

The problem is rendered more intricate by the fact that the properties of the feed water vary greatly from district to district and also seasonally. The accompanying Table I gives a general picture of the quality of the water at the various depots, while Table II gives the hardness of the water at a number of representative centres. It is, of course, the quality of the water along the whole run of an engine which has to be taken into consideration and not that at the central depot.

After preliminary trials of the T.I.A. process, which were carried out at Avignon, had proved conclusive, it was decided in 1941 to apply the treatment to the locomotives from five different depots where the feed water was particularly bad. When in 1946 the first of 1300 engines of the type "141 R" were taken into service, the treatment was applied to them from the beginning.

TABLE I—*Quality of Feed Water at S.N.C.F. Depots*

Behaviour/constituents	Number of depots at which the water		
	(i) Is non-corrosive	(ii) is aggressive or corrosive	(iii) contains $CaSO_4$
No scale formation	17 (6) N.T.	10 (1) T.A.	5 (2) T.
Very little scale formation	12 (3) N.T.	—	4 (2) T.
Some scale formation	16 (5) N.T.	—	12 (0) T.
Carbonates	35 (26) T. 4* (3*) T.	— —	— —
Carbonates and sulphates	10 (4) T. 5* (2*) T.	— —	— —
Sulphates	12 (5) T. 2* (6*) T.	— —	— —

NOTES—Plain figures denote deposits with an annual consumption of 150,000 to 500,000 cubic metres. Figures in brackets denote depots with a higher consumption than this.
(*) Denotes pre-softening with lime-soda.
At a few depots, water is obtained from sources differing in quality; the sum total in the above table is, therefore, slightly larger than the actual number of depots.
N.T.=No treatment. T.=T.I.A. treatment. T.A.=Anti-corrosive T.I.A. treatment.

TABLE II.—*Water Hardness at Various French Depots*

(1 degree of total hardness=10 milligrammes of $CaCO_3$ per litre or equivalent of other salts, 1 degree of permanent hardness =13·6 milligrammes of $CaSO_4$ per litre.

Depot	Region	Degrees of hardness	
		Total	Permanent
Thionville... ...	Est	33–40	13–15
Rheims	Est		
La Rochelle ...	Ouest		
Louvres	Nord	90	50
Gardanne ...	Méditerranée ...	58	25
Chantilly	Nord	54	23
Avricourt	Est	45	19
Benestroff... ...	Est	37	17

TABLE III.—*Career of Four Locomotives Subjected to T.I.A. Treatment*, 1947–1956.

Locomotive No.	Total mileage, km	Regulation check-up		Actual repair work	
		Total hours	Hours in 1955	Total hours	Hours in 1955
141R–1156 ...	985,000	135·9	0·255	110·9	0·165
141R–1157 ...	982,443	166·1	0·311	134·35	0·221
141R–1158 ...	1,001,362	202·35	0·350	141·9	0·250
141R–1159 ...	985,231	192·1	0·354	150·65	0·284

The careers of four of these engines, which were attached to the Nice depot, are sketched in Table III, the last three of these being the ones which were exhibited. Altogether, the Armand treatment has been, and is being, applied to over 9000 locomotives on the French railways alone, in addition to which it is used by the S.N.C.F. for its crane and marine boilers. The mileages reached by the three demonstration locomotives at the times when periodic boiler rinsings and inspections were carried out are shown in Table IV.

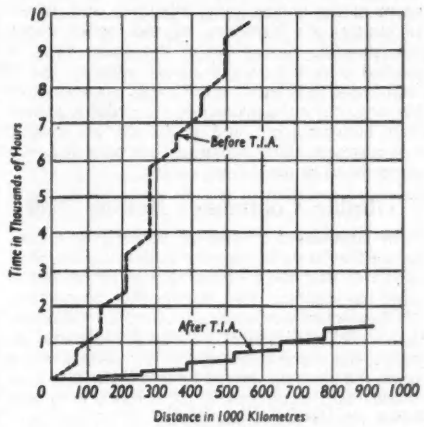
TABLE IV.—*Mileages of Demonstration Locomotives at Periodic Rinsings and Check-ups* (1000*km*).

Rinse No.	1	2	3	4	5	6
Approximate date ...	Mid-1948	End 1949	Beginning 1951	1952	1954	End 1955
Locomotive No.:						
141R–1157	109	258	419	601	760	938
141R–1158	111	260	428	618	776	—
141R–1159	112	263	433	588	749	945

For a comparable mileage without T.I.A., it would be expected that eleven rinsings and overhauls, and four major overhauls involving extensive reconstruction, would be necessary. On the other hand, the total maintenance with T.I.A. in the case of the four locomotives of Table III was of the order of 300 hours per 1,000,000km, or eighteen minutes per 1000km, of which eight minutes were spent on the boiler itself. Of these eight minutes, 90 per cent was preventive maintenance of stay bolts, with hardly any work on the fireboxes, and 10 per cent was spent on replacement of worn components and other work, which amounted to the following total for the four engines: Five superheater tubes, eight stay bolts, one smoke tube, one repair by arc welding of a cracked siphon.

By contrast, experience prior to the introduction of T.I.A. had shown that in spite of rinsing the boilers every 800km to 1500km, the effects of encrustation could only be reduced in degree. Leaks developed at the expanded tube-end after 10,000km, necessitating further expansion or beading-over of the ends, which, in turn, tended to cause cracks in the boiler plates. After every 60,000km, a complete renewal of the tubes became necessary, together with reinforcement of the firebox top and sides, while between rinsings at least 600 to 800 stay bolts had to be replaced.

A comparison between the times spent on boiler maintenance of all kinds before and after the introduction of T.I.A. is given in the diagram.



Average time spent on boiler maintenance for each locomotive

The ratio of the maintenance times, during the mileage for which a comparison is possible, is of the order of 16 : 1. Even higher ratios, of the order of 90 or 100 : 1, were obtained by similarly comparing the four "millionaire" locomotives with the "Pacific" engines previously in operation on the same run, between Nice and Marseille. The "Pacifics" operated on feed water pretreated with lime and soda, and used descaling compounds. The contrast becomes sharper when one realises that the average evaporative rate of the "Pacific" is 120 litres per kilometre, compared with 180 litres per kilometre for the "141R." The "as new" appearance of the "141R" boilers is very striking, in view of the fact that in the course of the last ten years each locomotive has evaporated some 180,000 cubic metres of water, containing enough salts to form 50 tons of scale (or 30 tons if lime-soda water treatment is employed), of which rinsing could have removed only 20 to 30 per cent.

In addition to savings on maintenance costs, the T.I.A. treatment increases the availability by 40 per cent and results in a reduction of the average fuel consumption from 65kg to 52·4kg per 1000 tonne-kilometres (gross).

The Traitement Interne Integral Armand is a combined chemical and physical process. The chemical complex, which, in its liquid form, is automatically added to the water in the tender by means of a simple level-operated siphon device, comprises the following factors which must be closely adjusted to suit the particular kind of feed water. It contains sodium and potassium salts which immediately precipitate calcium and magnesium. These precipitates are prevented from building up into the usual agglomerations by means of colloids which get absorbed on the surface of the crystallites and thus keep these separate and in a form in which they can be readily removed. The amount of dissolved oxygen is fixed, and cathodic and anodic reactions are blocked by the addition of powerful reducing agents in conjunction with the alkalis present, and in this way corrosion is eliminated. The use of retarding agents prevents the precipitation of salts in the feed passages, while anti-fouling compounds permit a greater alkalinity and salinity in the boilers without danger of algæ.

With the general introduction of the new method, water softening by means of lime and

soda is in the great majority of cases no longer necessary, and out of thirty-six softening installations eighteen have already been discontinued.

The precipitated salts collect at the bottom of the boiler in the form of mud, and are removed by periodically blowing down. Besides the mud, a certain amount of boiler water is blown off at the same time and replaced by water with a smaller mineral content, the actual quantity depending on the nature of the water, but being of the order of 3 per cent. This is done to keep the salt content below a certain figure, since it has been found that above that figure there is a risk, under the existing conditions of alkalinity and absence of oxygen, of electro-chemical corrosion and growth of algæ.

Control of the process is exercised by measurement of the conductivity, alkalinity and, where necessary, the hardness, of the boiler water. The periodic rinsing out of the boiler must be carried out in a very thorough manner and if that is not possible on a particular occasion, it is better to defer the operation. In order to ensure that blowing down and extraction are carried out correctly, these operations are recorded on a paper band in the driving cabin.

Tiltable Continuous Rolling Mill

In continuous rolling of sections and flats, as well as rounds, squares and hexagons, it is desirable that the material should be twisted as little as possible. For high quality production, to close tolerances, rolling is effected in alternate horizontal and vertical stands with intermediate loops, the requisite number of stands depending upon the kind of material to be rolled. For flats, mainly horizontal stands are needed, with only a few vertical stands for edging.

While continuous mills are operated most economically on a single programme, a mixed output programme is often required. If horizontal and vertical stands were to be put up as required by the different programmes, this would result in a large number of stands not all of which would be fully utilised. Moreover, at any one time only part of the electrical drives would be in operation. This rolling programme of a single-purpose mill can, to some degree, be extended by suitable roll design, and by using two-stand rolling also in the vertical stands.

A different approach was made by Schloemann A.G., Düsseldorf, by developing a design which we show in the accompanying illustrations, which can be used in the same location either as a horizontal or as a vertical stand. For operation in the horizontal position, the stand is driven in the conventional manner from the side. It can be tilted through 90 deg. to operate as a vertical stand, and is then driven through bevel gears either from below (as shown) or from above. The same guide housings are used for either position, as shown in the illustrations. This reduces to a minimum the number of roll stands and drives required for a given number of rolling programmes.

"Railway Wagon of the Future"

In 1951 the International Union of Railways (UIC), through the agency of its Office for Research and Experiments (ORE), standardised on known and well-tried designs of railway wagons in order to build up a homogeneous stock which would quickly give all the advantages from working in a European pool. At the same time it was emphasised by UIC that railways should modernise their rolling stock periodically and more frequently than now and therefore could study the possibility of constructing stock with a shorter life than the usual forty to fifty years, without, of course, worsening the economy of operation, but, on the contrary, trying to improve it.

At conferences between ORE and industry this new policy was discussed, and it was partly these discussions which led to the design competition for "The Wagon of the Future," which was announced by UIC in the spring of 1954. The idea itself was proposed during the second conference between ORE and industry, on February 16, 1953, by the Association Internationale des Constructeurs de Matériel Roulant (AICMR), to Mr. den Hollander, president of the ORE control committee. After discussion the conditions were agreed upon, and the last date for submitting proposals was fixed to be May 31, 1955. Nineteen firms from six different countries entered the competition, each of them anonymously. A mixed jury consisting of five railway engineers from different countries, appointed as authorities on wagon construction and maintenance, and five highly qualified engineers from wagon building firms, with Mr. Cuttica, Deputy General Manager of the Italian State Railways, as chairman, were occupied during the last months of 1955 and the beginning of 1956 with a very full study of the proposals and the marking of the entries. Three prizes totalling 95,000 guilders and bonus prizes totalling 25,000 guilders had been offered, sixty out of one hundred marks, or over, being required for the first prize. A special system of weighting emphasised the relative importance of the various factors which the designers had to bear in mind. These were: the reduction in the (averaged) annual redemption payments on capital, and the cost of periodic maintenance; reduction in operating cost; reduction of life in order to permit speedier modernisation; advantages to the railways' clientele, &c.

The competition results were officially published during the fourth conference between ORE and industry, held at Utrecht on April 25th this year. The prizes were awarded in that order to Waggonfabrik Uerdingen A.G., Krefeld-Uerdingen (German Federal Republic), Etablissements Industriels Soulé, Bagnères-de-Bigorre (France), and Etablissements Arbel, 24, rue du Rocher, Paris (France). Bonus prizes were awarded to M.A.N. Maschinenfabrik Augsburg-Nürnberg A.G., Werk Nürnberg, Nuremburg (German Federal Republic), Usines Ragheno, Mechlin (Belgium), Ateliers de Construction du Nord de la France, 54, Avenue Marceau, Paris (France), and Christ. Olsson i Falkenberg A.B., Orrspelsvägen 38, Bromma (Sweden).

Immediately after these results had been announced, ORE occupied itself with the way in which the results will be applied by the railways. The guiding principle in these deliberations was that this had been a competition of ideas, some of which had as yet to be proved in practice. It was decided at a joint meeting between ORE, the jury, and the winning firms to proceed in close co-operation between the railways and manufacturers to be specified, and in the first instance to construct and test a number of prototypes. It is hoped that strength tests will make apparent the relative advantages and disadvantages of rigid underframes, as well as of those based on a diagonal-elastic construction. The second stage will then be the study of the wagon of the future, properly so-called, which will be a synthesis of the best ideas put forward by the competitors, and of new findings which may emerge in the course of the work.

Adjustable Caliper Gauge

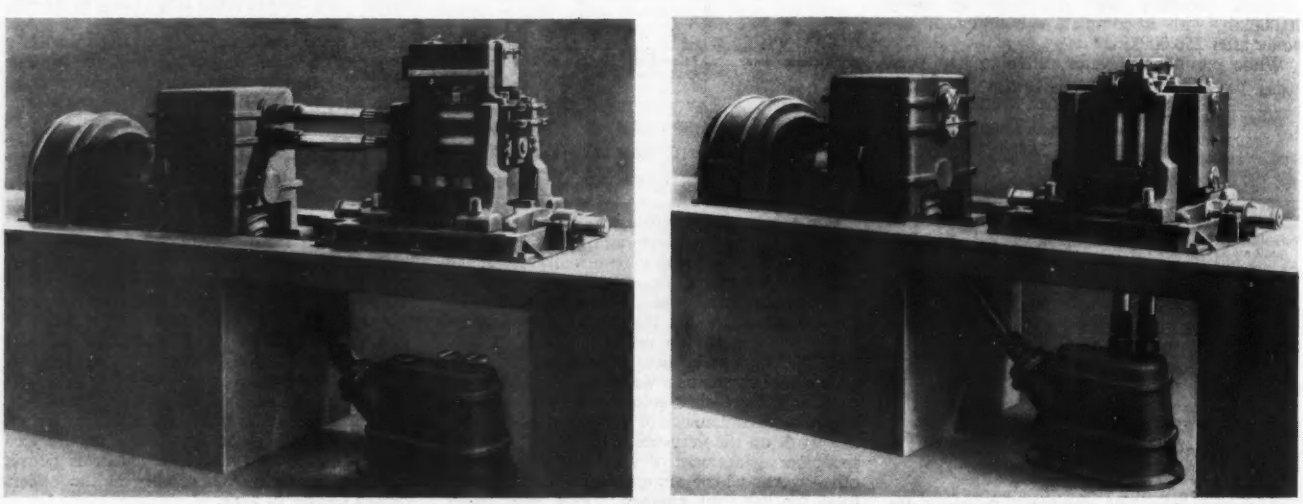
We have received details of an adjustable caliper gauge, put on the market by Wilh. AD. Kunkel O.H.G., Aschaffenburg/Main, German Federal Republic. This gauge is equipped with two pairs of cylindrical buttons, one giving the "go" size and the other the "not go" size of a component, the latter being distinguished by small discs. The buttons are fitted to the main body of the gauge by means of eccentrically ground pins which, when turned, permit the gauge to be adjusted by the use of gauge blocks to any degree of fit required.

German "Deep Freeze Chain"

A working party, "German Deep Freeze Chain," has been formed recently in Bad Homburg from among the refrigeration industry. Its task will be to do preliminary work for the Deep Freeze Association, which will lay down standards of quality in this field, to be maintained by a voluntary control board. The creation of a mark of quality will be considered, also the question of standardisation of packages and weights of deep-frozen goods, and the equipment which will be required.

Swiss Imports of Motor Vehicles

During the first three months of this year Switzerland imported 32,800 motor vehicles, or 4000 more than in the corresponding period of last year. In the automobile sector the figure is 18,902, representing a total of 107·2 million Swiss francs. Two-wheeled vehicles amounted to 13,909 machines, valued at 11·2 million Swiss francs.



On the left a tiltable continuous rolling mill arranged as a horizontal mill; on the right, the same mill in vertical position, driven through bevel gears

Measurement and Analysis of Industrial Noise

BY OUR AMERICAN EDITOR

In recent years industrial noise has come to be regarded as a "public problem" in the United States, and the engineering industry particularly is to-day faced with damage suits for occupational loss of hearing amounting to millions of dollars. In an effort to assist the work of acoustical engineers, the Mine Safety Appliances Company, of Pittsburgh, Pennsylvania, recently developed a portable electronic instrument to be used in noise surveys. The instrument, which is known as the "Soundscope," measures overall sound levels, analyses noise peaks at various frequencies and comprises electrical and acoustical calibrating devices.

IT is well known that the human ear hears only a limited amount of the sound which exists in Nature. This is because our ears are tuned to a narrow band of frequencies centred around those sounds which have value to us in the understanding of speech. Certain animals are able to hear sounds which are inaudible to human beings, but which carry meaning to them. In accordance with accepted theory, some of the sound waves in air, generated by a vibrating source enter the human ear canal and are directed down its length to the ear drum, which constitutes a dead end to the canal. In traversing the ear canal, the nature of the entering sound waves is altered somewhat because of the resonance of the canal. Certain sounds, especially those at frequencies of about 3000 c/s, are amplified. The ear drum is set into motion by the sound waves traversing the canal, and reproduces the nature of this wave motion very well. Embedded near the centre of the ear drum, which points inward, is the first of three small bones, or ossicles, which, linked together, carry the wave motion across a small air space to an opening in the opposite bone wall. The mechanism whereby wave motion in air is transformed to similar mechanical vibration is essentially that of a transducer. The difference in area between the ear drum and the opening in the inner bone wall, together with the lever-like action of the three ossicles, provide for an efficient transfer of energy in this process. Certain sounds, especially those between 1000 c/s and 5000 c/s, appear to be transmitted most efficiently by this mechanism. The faithful reproduction of the wave motion in air may be interfered with if the sound intensity striking the ear drum is high. In such a case the mode of vibration of the small bones may vary in such a manner as to produce distortion. This may also occur through the action of small muscles attached to the three bones and governing their motion. These muscles, the stapedius and tensor tympani, react in approximately 10 milliseconds when high-intensity sounds impinge upon the ear and serve to attenuate the passage of low-frequency sounds, primarily those below 1000 c/s.

The last of the three small bones, or the stapes, fits into the oval window, opening into the inner ear. Its base seals in the liquid of the inner ear, which fills a coiled tunnel, or cochlea, embedded in bone. A bony and fibrous shelf, the basilar membrane, separates the top and bottom halves of this cavity, with the upper part again being divided into two canals. Actually, only the base of the upper cavity is sealed by the stapes, while the base of the lower cavity is covered by a membrane. The two cavities spiral about each other and come together at the tip of two and a half complete turns. The mechanical vibration of the base of the stapes in its oval opening sets up similar wave motion in the fluid. As this wave motion traverses the upper spiral cavity it exerts pressure upon minute hair cells distributed on both sides of the Tunnel of Corti, which is situated on the basilar membrane. The nerve endings of the auditory portion of the VIII cranial never terminate at these hair cells. Depending upon frequency and intensity of the wave motion, certain hair cells of the Organ of Corti are displaced more than others, and thus certain nerve endings appear to receive more stimulation. Since the fluid in the cochlea is virtually incompressible, some means of relief must be provided for the pressure produced by the stapes. What occurs is that with inward movement of the stapes footplate in the oval window outward movements of opposite phase occur at the round window.

The pressure exerted upon the hair cells and nerve endings on the bony shelf in the cochlea appears to excite them in such a way as to set off the transmission of electrical nerve impulses. The wave motion in the fluid is coded in this way into a pattern of nerve impulses which travels along the auditory pathway to the parts of the brain which primarily are concerned with the appreciation of these impulses. Along the pathway to the brain there are also several relays which affect the transmission of the impulses. The auditory pathway itself is composed of many bundles of nerve fibres, some of which cross over from the right ear to the left side of the brain, and some of which cross over from the left ear to the right side of the brain. Some do not cross over but continue to the same side. The fluid in the inner ear cavities may also be set into motion when sounds of high intensity in the air set the human head into vibration, or when a vibrating object is held against the head. In either of these two situations the normal route of transmission through the vibration of ear drum and ossicles may be partially or entirely by-passed.

Through this process of transduction of energy it has been found that the average human hearing is limited in its range. In general, young adults can hear frequencies from 16 c/s up to almost 20,000 c/s. Certain frequencies are perceived at lower intensities than others. Going from 16 c/s up to about 2000 c/s it takes progressively less intensity for a tone to be barely heard. From 2000 c/s to higher frequencies greater intensity is required to make the tones audible. Thus is obtained a curve of hearing, or auditory sensitivity, which resembles a saucer, with perhaps the most sensitive hearing situated where it is needed for the hearing of speech. Another consideration in measuring the range of hearing is the limit of sound intensity which the ear or the human being with the ear can tolerate. In the normal ear, when sound intensities reach 100 db to 120 db, the owner of the ear complains that the sound is "uncomfortable." With about another 10 db he reports a "tickle," and at about 130 db to 140 db actual pain is reported. It is interesting to note that this tolerance threshold does not vary markedly with frequency, although it has been observed that higher frequencies are more unpleasant than lower frequencies of the same intensity. However, sound can produce auditory damage without noticeable pain or discomfort.

Effects of Noise

Ear damage from noise may be in the conductive mechanism of the ear, consisting of damage to the ear drum or to the three bones which transmit the vibratory energy across the middle ear to the inner ear. Under certain conditions the vibrations of these structures may become excessive with resultant damage. Tearing of the ear drum is the more common resultant of excessive pressure variations caused by intense sounds. Sudden intense sounds, rather than continuous sound stimulation, are the usual cause of tears or perforations of the ear drum. These tears apparently heal rather readily, and in the absence of subsequent infection of the middle ear do not of themselves result in a loss of hearing. In occasional cases healing does not occur completely, and in these cases some degree of hearing impairment will result. The degree of this conductive impairment will vary, but it may range from a mild to a moderate loss. The maximum hearing loss which may be caused by this conductive involvement will be of the order of approximately 50 db. Experience with soldiers exposed to explosions during the last war suggests that inner ear hearing loss was not as severe when the ear drum was ruptured as when it remained intact. It is surmised that the pressure wave impinges upon both the round and oval window at the same time when the ear drum is torn, thus preventing the delivery of this sudden sound energy to the more delicate structures of the inner ear.

When one speaks of noise having an effect upon hearing, the reference is usually to a raising of the threshold of hearing, requiring more acoustic energy before a sound is perceived. This raising of the threshold of hearing may be temporary, with a return to the previous level after a period of time, or it may be permanent. It appears that regardless of whether the shift of threshold is temporary or permanent, the structures involved are the hair cells against which the nerve endings terminate on the basilar membrane. A measurable temporary shift in threshold is now customarily called an "auditory fatigue," and the assumption implicit in this definition is the return to the previous threshold. It has been shown that this shift in auditory threshold occurs after exposure to other than high-intensity sounds, although the shift itself may then be of the order of a decibel or two. One might assume, therefore, that the ear is continually in a state of exposure and recovery, a continuous shifting of auditory threshold. This may be confirmed by the comparison of successive measurements of auditory threshold by audiometric testing.

When all or part of a shift in auditory threshold after exposure to noise remains after an extended period of time, it is assumed that the hearing loss is a permanent one. The length of time required to regain the pre-exposure threshold following auditory fatigue may be several days or more, although most of the recovery occurs very soon after the exposure. The permanent loss is the amount of shift remaining after complete recovery has been accomplished. The damage to the hair cells on the basilar membrane as a result of noise exposure appears to progress in stages, with the initial destruction involving hair cells along the outer side of the Organ of Corti. The hair cells along the inner side, as well as other structures of the Organ of Corti, may be destroyed progressively. Once established, the destruction of hair cells and other structures of the Organ of Corti is permanent in that no medical or surgical therapy is of value. It is a fact that these structures do not regenerate.

It appears that subsequent to noise exposure a particular section of the Organ of Corti, with its associated hair cells, is most frequently affected. This is true whether the resultant threshold shift is temporary or permanent. This part of the Organ of Corti lies along the first or basal turn of the cochlea, and is involved in the process of hearing high-frequency tones, specifically those with a frequency of about 4000 c/s. A continued exposure to noise following initial damage at about 4000 c/s may result in further loss of hearing for 4000 c/s, in addition to a gradual increase or spread in the direction of increasing loss for frequencies lower than 4000 c/s, until the hearing loss invades those frequencies concerned with the hearing of everyday speech. It is not until these subsequent stages are reached that the individual with the loss customarily notices any interference with his ability to hear.

Damage Criteria

Various levels of noise have been proposed as maximum safe levels below which men may work for extended periods of time without danger of resultant permanent hearing loss, and above which there may be risk of permanent damage of varying degree. Initial attempts to relate hearing loss to a single overall level obtained with sound meters have been made by several individuals. However, it is now apparent that it is not possible to specify

potentially damaging noise levels in terms of single overall sound meter readings. Because of the nature of the auditory mechanism, the frequency spectrum of the noise becomes an extremely important parameter. Basing his conclusions partly upon data presented by Fletcher, Kryter has presented an estimate of a maximum safe intensity. Fletcher suggested that the deafening effect of a critical band of frequencies is not enhanced by the addition of frequencies outside this band width. The band width is determined by the narrowest group of frequencies surrounding a frequency which barely masks the frequency when the band is of equivalent overall intensity. On the basis of a study of published data on industrial loss and laboratory evidence, Kryter estimated that 85 db for any frequency of less-than-critical band width was safe over an extended period of time.

This estimate has received widespread recognition, and has been converted into octave band levels by Parrack, who concludes that 95 per cent of workers exposed to noise up to or below this level for full working time over a period of several years will show no permanent damage to hearing. Some leeway is provided in that for short exposures somewhat higher levels may be tolerated. Some question has been raised concerning the Parrack criterion in that it does not take into account the manner in which the hair cells in the inner ear are stimulated relative to the nature of the stimulating sound. It has been pointed out that the frequency-sensitivity curve of the ear and the manner in which the ear perceives loudness are of importance in determining how sound may damage hearing, and there has been derived a series of equal sensation curves for broad band noise plotted in octave bands. On the basis of a large sample of industrial noises and an investigation of the nature of industrial hearing losses, a recent investigation concluded that "if the noise does not exceed 50 sones in any octave band, prolonged intermittent exposure will not result in hearing damage. On the other hand, if a worker works consistently in an environment which exceeds the 100 sones curve in any octave band, it appears that there is a strong possibility that hearing damage will result after a long period of time. The difference between these two limits is approximately 9 db."

Representative Noise Intensities

Noises measured in a quiet, suburban house at night give a value of about 27 db; an air raid siren measured 140 db at 50ft. The average factory has an overall sound level of about 75 db, and the test cell at an aircraft engine works measured as high as the air raid siren, 140 db. Industrial noise levels generally show anywhere from the 75 db noted as an average up to 120 db. Mr. G. L. Bonvallet, of the Armour Research Foundation, Illinois Institute of Technology, at Chicago, published the following table in September, 1952. It shows typical sound pressure levels as well as the relative energy generated by these levels :—

Condition	Sound pressure level, db.	Relative energy
Pain threshold	130–140	—
Feeling threshold	120	1,000,000,000,000
Aircraft interior	104	—
Very noisy factory	100	10,000,000,000
Underground train	94	—
Motor-car	92	—
Train	90	1,000,000,000
Street corner traffic, large city	75	—
Loud wireless set	74	—
Office	60	1,000,000
Average living-room	40	10,000
Very quiet home	20	100
Audibility threshold	0	1

Generally speaking, noise composed of the lower frequencies is less harmful than noise composed of high frequencies—up to a certain point, since frequencies above about 6000 c/s are usually considered as being less harmful. The human ear responds differently to different frequencies, so that a sound of low frequency must be louder in intensity to hear than a sound of higher frequency. Two scientists at the Bell Telephone Research Laboratories, after making extensive tests, established the fact that the normal ear is quite insensitive to the low frequencies, reaches its area of greatest sensitivity in the 4000 c/s region and then decreases at higher frequencies. The chart on which the average responses have been plotted is reprinted here. These curves are now commonly known as the "Fletcher-Munson Equal Loudness Contours."

Noise Measurement

Early noise measurement instruments used in America provided only crude data which did not meet the need of the hygienist. These meters were known as sound level meters and, for the most part, provided a reading of overall noise. As explained above, the human ear is not equally sensitive to all frequencies contained in noise, nor is it equally sensitive to damage at all frequencies. It is recognised, therefore, that the sound level meter is not adequate in defining exposure parameters. In view of this realisation instrument manufacturers developed what is known as the octave band analyser for noise measurements. This instrument can separate the audible spectrum into several discrete bands, each an octave wide, and quantitatively define the energy in each. Such an instrument gives greater physiological meaning to noise measurements than the earlier instruments, since the energy over a specific hearing region is known. The octave bands covered by these instruments were chosen on a practical basis, as follows. The first band measures the energy contained between the frequencies of 20 c/s and 75 c/s. The other bands are : 75–150, 150–300, 300–600, 600–1200, 1200–2400, 2400–4800 and 4800–9600 c/s. With such instruments the hygienist can determine the bands of greatest energy concentration and can, therefore, obtain a better evaluation of the biological effect of a given environmental noise exposure.

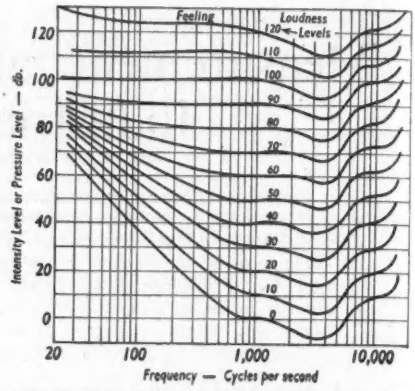
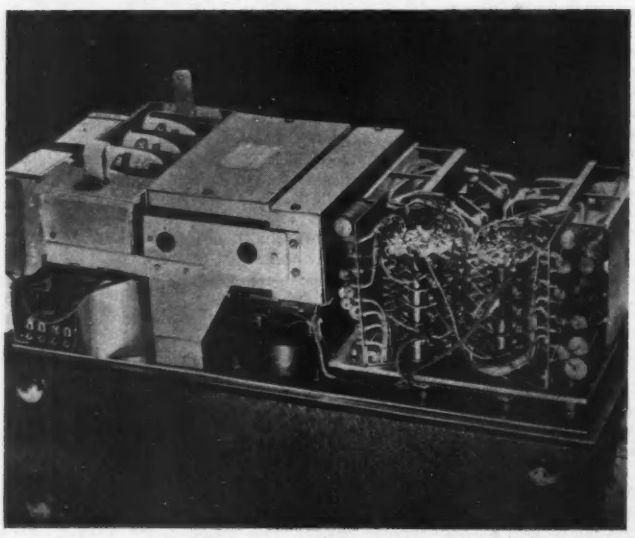
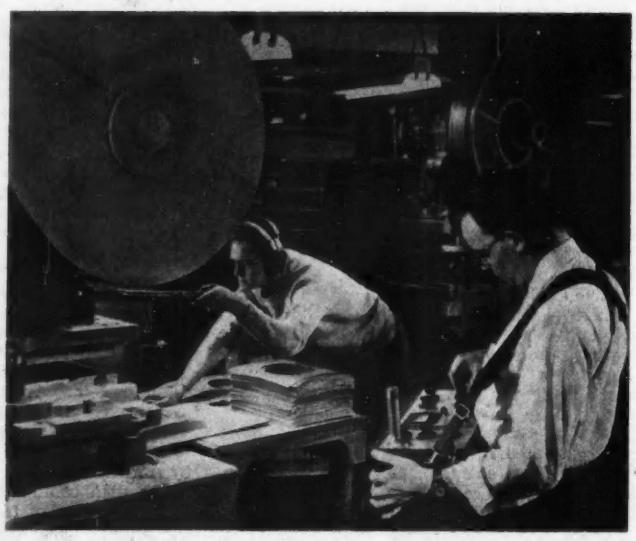


Fig. 1—Fletcher-Munson equal loudness contours

The "Soundscope" instrument has now been developed by the Mine Safety Appliances Company, of Pittsburgh, Pennsylvania, to replace several of the older instruments which were previously required to facilitate proper noise analysis. It can be used to measure overall noise in a manner similar to a sound level meter; it can be used to analyse this sound as an octave band oscillator and it can function as a narrow band analyser. It also has a built-in oscillator which serves as a source for electrical and acoustical calibration. The chief

Fig. 2—"Soundscope" noise measuring and analysing instrument





Figs. 3 and 4—(Left) Interior of "Soundscope" instrument showing electronic circuit components and batteries. (Right) Measurement and analysis of factory noise using the portable instrument

advantage of a small, complete unit of this scope is that it provides a versatile means of making a thorough " on the spot " analysis of a noise environment. This is important, since it is recognised that an octave band, or narrow band, analysis is needed in conjunction with an overall reading in almost all noise survey problems.

A careful design and selection of its component parts have made it possible to reduce the weight of this instrument to less than one-third that of older instruments. The fourteen " sub-miniature " vacuum valves used throughout the instrument have relatively low current drain, so that only the minimum of space is required to accommodate circuit components and batteries. To reduce the size still further, printed circuits are used in all amplifier and anode follower circuits. One of the problems faced in the design of this equipment is the prevention of erroneous readings caused by external mechanical or electrical vibrations. If an instrument is poorly designed in this respect, it is quite possible that a sizeable reading may occur when the microphone is completely detached. Errors resulting from microphonics can easily reach a magnitude of 30 db. In the present instrument, each vacuum valve is mounted on a shock-absorbent pad. The first valve of each amplifier has a metal wrapper which serves as a mechanical damper and also as an electrostatic shield. Each amplifier unit is completely encased in a metal box which is lined with a shock-absorbent padding. The metal enclosure provides additional electrical shielding, while the padding provides additional mechanical damping. In addition, the metal amplifier case itself is isolated from the rest of the instrument by means of rubber mounts. As an additional precaution, the outside case of the instrument is made of plywood having an aluminium shell. This combination of materials provides additional mechanical and electrical shielding, and durability. As a result of these precautions the makers claim that the " Soundscope " far exceeds the American Standards Association specifications on mechanical and electrical shielding.

Ease of operation is another important aspect to consider in the design of field instruments. Previously it has been necessary to take two or three instruments into the field to make a complete analysis of a noise environment. These instruments had to be connected with wires and the meters and dials of each instrument had to be included in each measurement. The operation of the present unit includes but one meter and one set of controls. In the " overall " position the " Soundscope " functions as a sound level meter ; i.e. as a microphone, an amplifier, an attenuator, and a meter. When measuring noises over 80 db, the first one of the two amplifiers is disconnected from the circuit. In the " analyser " position, an analyser, an analyser attenuator and an analyser amplifier are added to the " overall " circuitry. The analyser circuit is made up of a step-type filter and a continuously variable filter for both low and high-frequency cut-off. This permits an analysis of the noise spectrum by octave or narrower bands.

The electrical calibration is checked by comparing a standard electrical signal from the calibration oscillator to another signal from the oscillator which is directed through various parts of the circuit. Means are provided for adjusting the calibration to compensate for changes in battery voltage. The acoustical calibration is checked by comparing a standard acoustic signal to a specified meter reading. The standard acoustic signal is provided by a calibration loudspeaker which is driven by the internal oscillator.

To make an overall sound pressure level measurement, the function switch is turned to an " operate " position and the power-meter control to " overall." The " overall " attenuator is turned until the meter reads on scale. The overall sound pressure level is the algebraic sum of the attenuator setting and the meter reading. To analyse a noise, the power meter switch is turned to the analyser position and the low and high frequency cut-off controls are adjusted to pass the frequency band that is to be measured. A frequency cut-off is selected by adjusting the product of the two low, or high, frequency cut-off controls. For example, if an octave band control is set on 300 and the corresponding narrow band control is on 1·0, the cut-off frequency will be 300. If the narrow band control is moved to 2·0, the cut-off frequency will be changed to 600.

For purposes of demonstration the noises of a wood planer and a foundry vibrator were recorded. The overall levels are adjusted so that they read the same, and then an octave band analysis is made on each noise. These analyses are then compared with a damage risk estimate. According to the damage risk estimate, it is evident that workers exposed to the planer noise would be in greater danger of hearing damage than those exposed to the vibrator noise. This demonstration emphasised the importance of analysing the noise, since the overall readings or sound level meter readings would indicate the noise to be the same.

After an octave band analysis is run and the sound energy distribution is known in octave bands, it is sometimes necessary to determine the energy distribution inside an octave band. Perhaps the place where this information is most often needed is in an area where there are several noise sources and it is necessary to determine which source is generating a particular narrow frequency band. A narrow band analysis is made by setting both octave band controls at the same level and manipulating the narrow band controls to select the bands to be measured. For example, if it is necessary to make a narrow band analysis in the 1200–2400 octave band, both octave band controls are set at 1200. By manipulating the narrow band controls, the narrow bands may be selected. A means of locking the narrow band controls is provided at 10 per cent of an octave band.

An analyser input jack is provided so that the analyser section can be used by itself. For example, a tape recording can be analysed by inserting the electrical signal into the analyser input jack. A monitor output jack makes it possible to monitor the signal that is present across the db meter. Earphones may be connected through this jack to listen to the noise, an oscilloscope may be connected to observe the wave forms, or an external meter may be used to measure the signal.

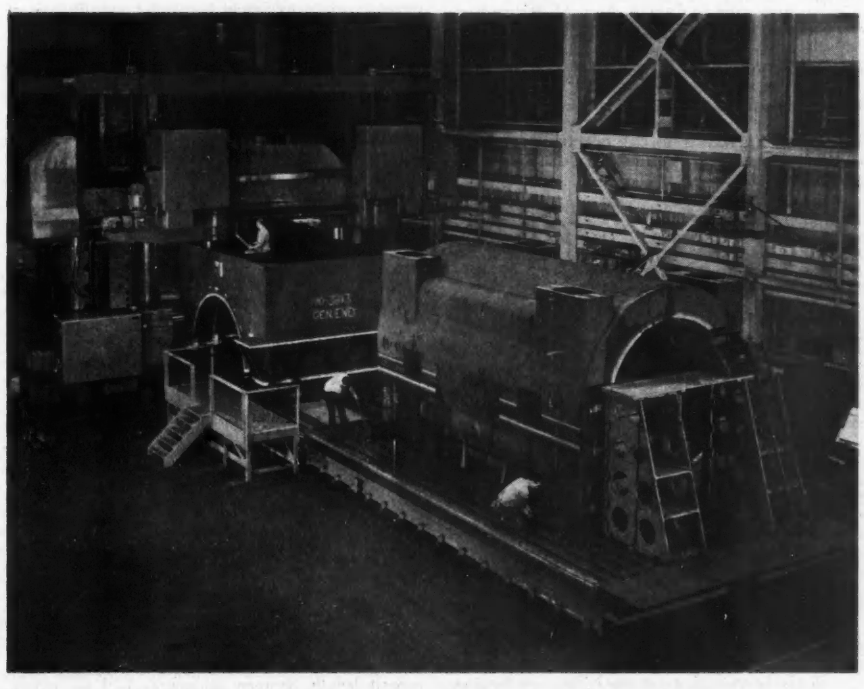
As a result of its portability, the new instrument is useful for drawing up noise contour maps of industrial areas. Such sound level readings and analyses of frequencies and intensities at different distances from noise sources can be used to plan a detailed map of an area indicating unsafe conditions. At present it is felt that three measures are possible to safeguard against occupational loss of hearing : (1) The elimination of noise at the source by redesigning machinery and equipment ; (2) the isolation of noise by insulation and special structures, and (3) the personal protection of the individuals exposed, using appropriately designed devices for this purpose.

Adjustable Rail Milling Machine

THE accompanying illustration shows what is believed to be the world's largest milling machine, which was recently completed by the Ingersoll Milling Machine Company, Rockford, Illinois. The illustration shows the condenser flange of a turbo-generator low-pressure hood being milled on one table, while a generator stator frame, weighing 62 tons, is being set up on a second work table. The adjustable rail milling machine weighs approximately 550 tons and will be used in the manufacture of large turbo-generator parts at the Schenectady, New York, works of the General Electric Company. The machine stands 35ft high, is 42ft wide and 120ft long overall. It is capable of working on components 18ft wide, 16ft high and over 50ft in length.

Work to be handled by the machine will consist primarily of massive but comparatively thin-walled steel weldments in which the moving parts of the turbine and the generator are encased. Most of the work on these weldments consists of machining horizontal and vertical joint surfaces so that when the parts are assembled they will form, with a minimum of hand work, steamtight fits. Interrupted cuts will be taken at high feed rates, yet the joint surfaces will be machined to tolerances of 0·003in, and to a high, almost mirror-like finish. The machine has horizontal cutting heads at both sides and two vertical cutting heads mounted on the adjustable cross rail above the work tables. Each head has an individual 100 h.p. drive motor and the total rating of all motors used in operating the machine is 575 h.p.

The workpieces are carried on two 17ft wide tables, which move along the 112ft bedways. The tables are 22ft and 30ft long, respectively. While work mounted on one table is being machined the other table is parked at one end of the machine for loading or unloading. One operator controls the various elements of the machine from a portable pendant. Waste metal chips removed in the machining process are carried away by power conveyors built into the foundation underneath the machine.



" Ingersoll " adjustable rail milling machine with dual work tables installed at the Schenectady works of the General Electric Company

Personal and Business

Appointments

MR. F. R. HORNBY has been appointed secretary of the National Council for Technological Awards.

MR. H. N. HACKING has been appointed works manager of Clifford Aero and Auto, Ltd., Birmingham.

MR. H. E. J. BUTLER has been elected national chairman of the Association of Supervising Electrical Engineers.

MR. BRIAN CAPE has been appointed technical services manager of Kelvin and Hughes (Aviation), Ltd., Basingstoke.

DR. R. LESSING has been nominated to succeed Sir Ernest Smith as president of the National Smoke Abatement Society.

TAYLOR WOODROW CONSTRUCTION, Ltd., states that Mr. Norman Baker, chief estimator, has been appointed a director.

MR. W. T. BOWEN has been appointed Midlands area director of Concrete, Ltd., 16, Northumberland Avenue, London, W.C.2.

REMINGTON RAND, Ltd., has announced the appointment of Mr. John F. Jakens as manager, mechanical services (Great Britain).

MR. HAROLD SAUNDERS has been appointed manager of the constructional engineering department of Thos. Storey (Engineers), Ltd., Stockport.

THE MINISTER OF TRANSPORT AND CIVIL AVIATION states that Sir Howard Roberts has been appointed an additional member of the Transport Tribunal.

THE NATURAL RUBBER DEVELOPMENT BOARD states that its rubber in roads research programme in the U.S.A. has been placed under the direction of Mr. J. York Welborn.

MR. S. R. HOWES has been appointed a director of The United Steel Companies, Ltd. He has just retired from the position of director and general manager of Samuel Fox and Co., Ltd.

MR. J. R. HUDSON has been appointed joint managing director of The Moss Gear Company, Ltd., Tyburn, Birmingham. Mr. A. W. Macferson has been appointed a director of the company.

THE MINISTRY OF TRANSPORT and Civil Aviation states that Mr. R. J. Shepherd, M.I.N.A., has been appointed principal sea transport surveyor, following the retirement of Mr. F. H. Morley, M.I.N.A., from the marine survey service.

SIR MILES THOMAS has now taken up the office of chairman of Monsanto Chemicals, Ltd., in succession to Mr. E. A. O'Neal Jun. Mr. Marshall E. Young, a vice-president of the Monsanto Chemical Company, has been elected to the board of Monsanto Chemicals, Ltd.

F. PERKINS, Ltd., Peterborough, states that Sir Richard Yeabsley has been appointed deputy chairman, in succession to Captain A. J. M. Richardson, who has resigned owing to pressure of other business. Mr. M. I. Prichard has been appointed deputy managing director.

MR. F. R. LIVOCK, M.I.Mech.E., M.I.E.E., has been appointed director of the British Institute of Management, in succession to the Hon. L. O. Russell. Mr. Livock has been a director of three of the engineering companies in the Metal Industries, Ltd., group since 1953.

THE IGRANIC ELECTRIC COMPANY, Ltd., announces the appointment of Mr. A. W. Page as sales manager with headquarters at Bedford. He is to be succeeded as London manager by Mr. E. G. Harrison, who will continue to act as the company's export manager at Victoria Station House, Victoria Street, S.W.1.

THE UNIVERSITY OF LONDON has notified the following appointments: Mr. M. W. Humphrey Davies to the chair of electrical engineering at Queen Mary College; Mr. P. T. Fink to the readership in aeronautics tenable at the Imperial College of Science and Technology; Dr. W. L. Wilcock to the readership in instrument technology tenable at the Imperial College of Science and Technology.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., Chelmsford, states that Mr. V. J. Cooper, M.I.E.E., has been appointed chief television engineer. Mr. G. E. Partington, A.M.I.E.E., has been appointed deputy chief television engineer. Three television development groups and an audio development group have been formed, under Mr. E. Davies, Mr. M. N. Parker-Smith, Mr. J. E. Nixon and Mr. S. J. Gooderham.

LLOYD'S REGISTER OF SHIPPING states that, in view of the expansion of its non-marine work, it has been decided to form a separate land division. Mr. E. Crossley is the managing engineer of this new division, and Mr. J. N. Buchanan becomes a principal surveyor in the division. Other appointments announced by Lloyd's Register are: Mr. G. Auterson, principal electrical engineer surveyor, in succession to Mr. G. O. Watson, who has retired but who will continue to serve as a consultant; Mr. W. Macmillan, principal surveyor in charge of the freeboard department. Mr. A. T. S. Sheffer, senior ship surveyor for Germany, has been given the rank of principal surveyor.

VICKERS, Ltd., states that Mr. A. H. Hird, A.C.G.I., M.I.Mech.E., has been appointed a special director and adviser on group commercial engineering sales. He is also taking over the chairmanship of A.B.C. Motors, Ltd., Cooke, Troughton and Simms, Ltd., and Ioco, Ltd. Mr. E. J. Waddington and Mr. R. P. H. Yapp have relinquished their seats on the boards of Ioco, Ltd., and Cooke, Troughton and Simms, Ltd., respectively, and Mr. Waddington has relinquished the chairmanship of A.B.C. Motors, Ltd., but remains a director of that company. Mr. R. Wonfor has been appointed sales director, and Mr. J. E. Richardson has been appointed a director of Vickers-Armstrongs (Engineers), Ltd. Rear-Admiral Sir Anthony Buzzard, Bt., has been appointed a special director of Vickers-Armstrongs, Ltd., and assistant to the managing director.

Business Announcements

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the telephone number of its Hull branch is now Hull 16367.

THE GENERAL ELECTRIC COMPANY, Ltd., states that the telephone number of its research laboratories at Wembley has been changed to Arnold 1262.

DARWINS, Ltd., states that its subsidiary, J. Stead and Co., Ltd., has acquired the screwdriver manufacturing division of Endo Industries, Ltd., Redditch.

THE TRIPLEX group states that a new factory is to be built at Stour Street, Spring Hill, Birmingham, for its engineering companies, Stern and Bell, Ltd., and Weldall and Assembly, Ltd.

A.E.I.-JOHN THOMPSON NUCLEAR ENERGY COMPANY, Ltd., has announced that Balfour, Beatty and Co., Ltd., and John Laing and Son, Ltd., are to act as its civil engineering contractors.

MR. J. B. MAVOR, formerly chairman of Mavor and Coulson, Ltd., has received the honorary degree of Doctor of Laws from the University of Glasgow, in recognition of his long service to the city and to education in Scotland.

ROBERT HUDSON, Ltd., states that the address of its London office is now Locomotive House, 30–34, Buckingham Gate, S.W.1 (telephone, Abbey 7127). Mr. Francis Theakston, the London director, continues to take charge of the office.

STANDARD TELEPHONES AND CABLES, Ltd., has opened regional offices at Norwich Union Buildings, City Square, Leeds, 1, and at 49, Queen Street, Glasgow, C.1. A new cable warehouse has been opened at Endle Street, Southampton (telephone, Southampton 21563).

MR. H. H. SWIFT, M.I.E.E., is retiring at the end of July from the position of chief mechanical and electrical engineer, Southern Region of British Railways. Mr. Swift joined the British railway service in 1936, as assistant electrical engineer on the L.N.E.R. Prior to that he was on the staff of The English Electric Company, Ltd.

THE NORTHERN IRELAND MINISTER OF COMMERCE has announced that a new company entitled Bessbrook Products, Ltd., is to be established by Pye, Ltd., in association with The Aberdare Electric Company, Ltd., for the manufacture of electrical products. The Ministry has agreed to build a factory of approximately 30,000 square feet for the company at Bessbrook, Co. Armagh.

Contracts

VICKERS-ARMSTRONGS, Ltd., is to supply seven "Viscount" V.810 airliners with R.R. "Dart" R.D. 7/1 engines to Lufthansa, which has also taken an option on two more similar aircraft. Delivery will start late in 1958. The total number of "Viscounts" now ordered is 323.

DORMAN LONG (BRIDGE AND ENGINEERING), Ltd., Middlesbrough, has received the contract from the Iraq Government Development Board for the building of the Qurnah Highway bridge over the River Euphrates. The value of the contract is £420,733. The structure will be a nine-span bridge of continuous plate girder construction on piled foundations. The overall length between abutments will be 1020ft, with a deck 40ft wide.

THE AUTOMATIC TELEPHONE AND ELECTRIC COMPANY, Ltd., has received an order from the New Zealand Post and Telegraph Department to supply equipment for the first coaxial cable telecommunications system ever to be installed in New Zealand. The new system, which will link the North Island centres of Auckland and Hamilton, will cater initially for 240 telephone circuits. As traffic demands grow, provision has been made to increase this number to 960 circuits. Fourteen unattended repeater stations will be used along the 80-mile route separating the two cities, which in the past have been served by carrier systems on overhead wires. The coaxial cable on which the new equipment will work has been supplied by British Insulated Callender's Cables, Ltd.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has received an order from the Electriciteitsbedrijf Zuid-Holland N.V. (South Holland Power Supply Company) for two 75MVA power transformers for installation at the Marconistraat sub-station in Rotterdam. They will be three-phase, 50 c/s, star/star/delta-connected units with ON/OB cooling, and having a voltage ratio at no-load of 150/26·25/10·5kV. They will be designed to have low losses, and the cores will be made of cold-reduced grain-oriented directional sheet steel. The high voltage windings will have an impulse withstand level of 750kV. They will be provided with eighteen tappings over a range of plus and minus 15 per cent and will be fitted with the M-V type H on-load tap-changing switch, arranged for remote electrical control.

Miscellanea

LIGHT COMMERCIAL VEHICLES.—The British Motor Corporation has added to its Austin and Morris ranges a series of light commercial vehicles available in either van, truck or pick-up, or coach form. All models have the 1489 c.c. "B" series engine, giving 42 h.p. at 4000 r.p.m., and located below the front seats. The van is fitted with sliding front doors, the truck with a separate cab. The coach, to carry nine or twelve passengers, has hinged doors to the driver's compartment, at the side and at the back.

FILMS.—Three films recently completed by Technical and Scientific Films, Ltd., were shown in London last week. "Home and Away, No. 5," is the latest in a series of magazine films made for Babcock and Wilcox, Ltd., "Any Questions on Cotton" has been prepared for the Cotton Board and is directed to all users of cotton, and "One Man and His Job" is the latest addition to a series of films commissioned by the British Productivity Council. It illustrates the methods used to study, and then simplify, the movements of one man assembling many intricate component parts into a complete unit.

OPEN DAYS AT EAST KILBRIDE.—The Mechanical Engineering Research Laboratory, East Kilbride, Glasgow, is to hold its first open days on Thursday and Friday, September 20th and 21st. Applications for invitations, stating which day is preferred, should be sent to the Director. It is stated that the work on show will cover properties and mechanics of materials, particularly fatigue and creep; fluid mechanics, including water turbines, pumps and oil pressure mechanisms; lubrication and wear; mechanisms, engineering metrology, and noise control; machining, extrusion, forging and other metal-working processes, and heat transfer and thermodynamics.

PUMP MANUFACTURING FIRM'S ANNIVERSARY.—Mono Pumps, Ltd., first began to manufacture pumps in 1935. Since its inception the firm has steadily expanded and its pumps have been developed to cover a wide range of industrial applications, the most recent of which is the pumping of dry powders. A year or so after its inception the firm became associated with J. and E. Arnfield, Ltd., for the manufacture of its pumps and in 1938 a works was equipped at Audenshaw, near Manchester, for the production of Arnfield textile machines and Mono pumps. Shortly after the war the two firms entered the Gallaher group of companies, and excess productive capacity at the works was taken over for the manufacture of cigarette-making machines. To mark its twenty-first anniversary, Mono Pumps, Ltd., recently held a luncheon and reception at the works, and visitors were given an opportunity to see much of the special equipment developed for the batch production of its pumps. The pumps exhibited at the works included a new product known as the "Monocore" pump, about to go into production. This pump will have a capacity at present beyond the capacity of the Mono pump and is expected to have a number of new applications in the oil industry.

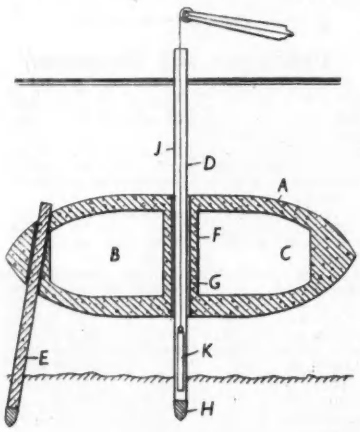
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

CIVIL ENGINEERING

749,979. September 27, 1954.—PILE ANCHORAGE OF SUBMERGED STRUCTURES, Guy Anson Maunsell, 41, Abbey House, Victoria Street, London, S.W.1.

The invention relates to the form of subway or other submerged structure which is supported from the bottom of the river or estuary by means of piles. The drawing shows a cross-section of a reinforced concrete tubular subway *A* which, after being precast in a graving dock, is towed out with its ends blocked to exclude water from the traffic ways or galleries *B* and *C*. In the drawing the segment is shown after it has been lowered and connected to the previously fixed part of the subway and whilst it is in process of being connected to the ground by means of special tubular piles *D* and *E*.



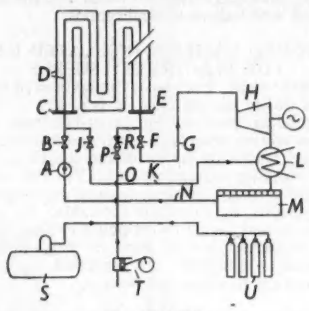
No. 749,979

In the position shown, the galleries *B* and *C* are filled with air at atmospheric pressure so that the men can work in them. Cast in the body of the middle wall *F* are one or more holes, each having a light steel tubular sheath *G* around which the wall was precast. When the segment is first lowered the hole within the sheath is full of water. The pile or piles *D* consist of a closed point *H*, and a hollow steel tubular shank *J*. The pile is slightly smaller in diameter than the sheath. The pile is driven into the ground by means of the cylindrical drop hammer *K*, the hammer striking the point *H* directly. When the desired penetration has been obtained the pile is rigidly connected to the segment by cement grouting the annular space between the shank *J* and the sheath *G*. Inclined piles intended to resist lateral displacement of the subway segment may also be sited as shown at *E*.—*June* 6, 1956.

STEAM GENERATORS

750,071. August 30, 1954.—EXPELLING WATER FROM TUBE SYSTEMS, Sulzer Frères Société Anonyme, Winterthur, Switzerland.

The invention relates to a method of expelling water from a once-through tube system of a steam generator after the fire is extinguished. Such tube systems may include all the heating surfaces of a forced flow steam generator, and the superheater and economiser heating surfaces of a natural flow steam generator. In normal operation of the steam generator, shown in the drawing, a pump *A*, a feed pump or a forced circulation pump, delivers water through a valve *B* into the inlet header *C* of the steam generator tube system *D*, which can be either the complete tube system of the steam generator or a sub-unit of the complete tube system. The generated steam leaves the tube system *D* through an outlet header *E* and flows through a valve *F* into a steam main *G*, which can lead either to further heating surfaces or to a prime mover *H* such as a turbine. When the steam generator is to be shut down, the fire is first extinguished and afterwards the valve *B* is closed and thereafter also the valve *F*. At the same time a valve *J* in a pipe *K* which branches off from the water supply pipe is opened. The pipe *K* preferably leads to the condenser *L* of the prime mover. Steam is now produced in the tube system owing to the reduction in pressure, and expands to expel the water contained in the tubes out through the pipe *K*. The greater part of the water content is removed in this way. It flows off from the condenser *L* into the feed water reservoir *M* and is collected there, to be drawn off by the pump *A* through a pipe *N* when the steam generator is restarted. Moisture residues can best be removed after this expelling operation by blowing a gas, for example, air, through a pipe *O*, a valve *P* and a non-return valve *R* into the steam main *G*, to dry out the tube system, in conjunction with



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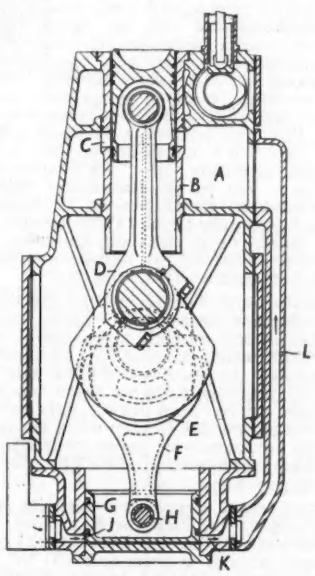
the heat still contained in the furnace. If the steam produced in the tube system itself does not possess sufficient energy for expelling the water, steam can be blown in through the pipe *P* from another boiler *S*, or compressed air pumped in by a compressor *T*, or even an inert gas or a gas having corrosion inhibiting properties blown in from a battery of pressure cylinders *U*. It is sufficient to provide only one of these expedients in any one plant. A modified system is also shown in the specification.—*June* 6, 1956.

INTERNAL COMBUSTION ENGINES

749,864. October 5, 1953.—BALANCING AND CHARGING OF ENGINES, Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., 121, Queen Victoria Street, London, E.C.4. (*Inventors: James John Stewart Smith and Leonard Percy Bagge.*)

The invention relates to the balancing and charging of internal combustion engines, and its object is to use charging means to provide an engine with improved balance. Referring to the design shown in the drawing, the working piston is fastened to the connecting rod by a gudgeon pin in the normal manner. The engine is of the two-stroke cycle type and has an air capacity chamber *A* around the cylinder walls *B* in which inlet ports *C* are provided, there being a poppet type exhaust valve in the cylinder head. The large end *D* of the connecting rod is split and bolted together around the crank pin in the usual way. Crank webs are provided at

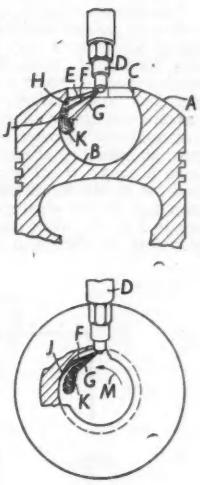


No. 749,864

each end of the crank pin and eccentrics *E* are machined on the outer faces of the webs. A forked strap or connecting link *F* is fitted on each of these eccentrics; on the other end of each an auxiliary piston *G* is attached by means of the gudgeon pin *H*. It will be seen that the crank pin of the working piston *A* and the eccentrics of the piston *G* are opposed to one another with the result that their revolving forces and inertia forces are opposed to one another and thus, by suitable arrangement of the weights of the moving parts, the engine can be completely balanced or at least can be arranged to give only very slight out of balance forces. To achieve complete balance the ratio of the connecting rod length to the crank radius in both instances requires to be the same with suitable adjustments of the weights of the moving parts. Inlet and outlet ports *J* and *K* controlled by non-return valves allow entry of air to the cylinder of the piston *G*, while the air is forced out of the cylinder by way of the non-return valve and the air passage *L* to the chamber *A*. A modified arrangement is also shown in the specification.—*June* 6, 1956.

749,825. December 2, 1952.—FUEL INJECTION, Hans Krug, Stadtpark 33d, München-Pasing, Germany.

The invention consists in a process of forming the mixture of fuel and air in a compression ignition engine, with a combustion chamber having a spherical shape. Referring to the drawing, the domed head *A* of the piston contains a spherical combustion chamber *B*. The outlet opening of the chamber towards the cylinder space is a short cylindrical passage *C*. The fuel nozzle *D* is inclined to the axis in the cylinder of the combustion chamber passing through the opening and offset to the axis. The fuel jets *E*, *F* and *G* impinge at the points on the wall of the combustion chamber, so that films *H*, *J* and *K* are formed on it. The fuel is directed to the wall of the combustion chamber from an initial position where it leaves the fuel nozzle, which is arranged very close to the wall of the opening of the combustion chamber. The fuel jet or jets meet the wall of the combustion chamber at a small angle of inter-section with respect to the curvature of the wall and the fuel flows over the wall without reflection and spreads out on it in the form of a film. This superficial spreading of the fuel over the wall of the combustion chamber undisturbed by reflection is shown at *K* in the lower view for the jet *G*, which also is directed to the wall of the chamber at a very small angle of intersection with respect to the curvature of the surface of the wall but somewhat different from the angle of jet *G*. In this view the section is through the fuel jet *F*. The flat or nearly tangential impingement of the jet *F* and the formation of the film *J* or the film *K* originating from the fuel jets *F* and *G* is clearly visible. The arrow *M* indicates in which direction the rotary motion of the combustion air in the chamber *B* takes place, the fuel being injected in the general direction of the motion of the air in order that the air does not break up the fuel jets but assists the fuel to spread out over the wall of the chamber. The air sweeps over the wall of the chamber so that the fuel is removed from the wall only in the form of a vapour. The inlet duct arrangement for a four-cylinder engine is also shown in the specification.—*June* 6, 1956.

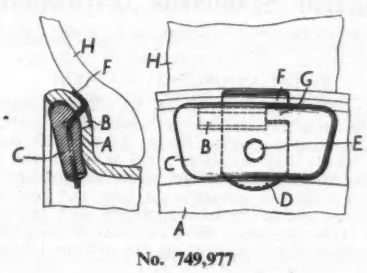


No. 749,825

ROAD TRANSPORT

749,977. August 27, 1954.—BALANCING OF ROAD WHEELS, Daimler-Benz Aktiengesellschaft, Stuttgart-Untertürkheim, Germany.

A previous specification, No. 703,044, describes an arrangement for balancing a road wheel by a weight mounted in an opening in the rim of the wheel and held in position by the pressure of a tyre.



No. 749,977

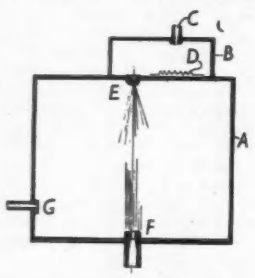
The present invention is concerned with improvements in that arrangement. As shown in the drawing, the rim *A* of a motor vehicle wheel has a slot-shaped

opening *B* in which the balancing weight *C* is suspended. The weight is secured by a part *D* which is anchored to the weight by the filling of a bore *E* in the part. The part *D* is inserted through the opening *B* and hooked to the edge of the rim by means of extension *F*, so that it firmly pulls the weight against the edge of the rim. The arrangement is such that the weight will be caused to bear more firmly against the edge of the rim by the effect of the centrifugal force set up when the wheel is rotating. For the purpose of the invention, the part *D* is provided, in the region of its bent portion, with a lateral recess in the form of a notch *G* which corresponds in width to the wall thickness of the rim. After the securing part has been inserted through the opening in the rim, it can, with the weight, be displaced in the circumferential direction, so that the edge of the opening *B* engages in the recess *G*, as shown. Additional security against disengagement of the balancing weight held to the rim by the tyre *H* is thereby achieved.—*June* 6, 1956.

GAS TURBINES

749,921. October 22, 1953.—FUEL SUPPLY SYSTEMS FOR REACTION CHAMBERS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventors: Douglas Francis Welch, Kenneth Barrington Randall and Ian Gourlay Strang.*)

The invention relates to apparatus for generating a flow of gaseous working fluid to produce a high energy output for a short period. The working fluid may, for example, be supplied to a turbo-starter for a prime mover, of which a gas turbine is an example. Referring to the drawing, a main reaction chamber *A* has mounted upon it an auxiliary reaction chamber *B*. The auxiliary chamber is provided with monofuel from an atomising nozzle *C*, which injects monofuel upon a heater *D*. The heater is preferably in the form of an electric heating element. Decomposed monofuel in the chamber *B* is exhausted via the nozzle *E* to the main reaction chamber. A jet of monofuel is supplied to the main chamber via a



No. 749,921

non-atomising nozzle *F*. The nozzles *E* and *F* are substantially in line, the decomposed fuel issuing from nozzle *E* being thus able to impinge upon the jet of fuel issuing from the nozzle *F*. The general collision and turbulence of the liquid fuel stream and molecules of decomposed fuel promotes decomposition of the jet of fuel from the nozzle *F*. The exhaust nozzle from the main reaction chamber is shown at *G*, and this is capable of connnection to a utilisation device for the blast of working fluid produced within the main reaction chamber *A*. It will be appreciated that the auxiliary reaction chamber must continue to function during the complete cycle of operation, and that it cannot be switched off when self-sustained decomposition of fuel is effected in the main reaction chamber. Finally, while the nozzles *E* and *F* may be arranged as shown in the drawing, it is preferable in certain cases to provide a pipe or passage to convey the decomposed fuel from *E* to the vicinity of the nozzle *F* and its fuel jet.—*June* 6, 1956.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

SHAFT COUPLING FLANGES

No. 2715 : 1956. Price 2s. 6d. This standard applies primarily to internal combustion engines incorporating a coupling flange, for use with rigid and flexible shaft couplings; but it refers also to similar applications where interchangeability of mating flanges is necessary. It does not refer to couplings used in special applications, such as overhead cranes involving heavy reversals of stress and long shafts subject to bending, nor to those covered by B.S. 664, "Cast Iron Shaft Couplings (Rigid Flanged Type with Recessed Bolt-Heads and Nuts)."

The standard specifies the dimensions of shaft coupling flanges, for engine and electric motor drives, necessary to ensure interchangeability, within the range of pitch circle diameters of bolt holes from 3¼in to 9½in. It does not apply to shaft coupling flanges with fitted bolts. Flange thicknesses are not specified, since this dimension varies with the material used and with individual applications.

VARNISHED CAMBRIC INSULATED CABLES FOR ELECTRICITY SUPPLY

No. 608 : 1956. Price 6s.—This revision of B.S. 608 follows closely on the lines of B.S. 480 : 1954, the corresponding standard for paper-insulated cables. The new edition deals with taped and braided cables with lead, lead-alloy or aluminium sheathing. They are for working voltages up to 11kV. The standard includes "quality" clauses governing the composition of the various components of the cable. As in other recently revised standards for power cables, the basic reference temperature is now 20 deg. Cent. and "nominal" diameters are specified instead of maximum and minimum diameters.

NON-FERROUS PIPES AND PIPING INSTALLATIONS FOR AND IN CONNECTION WITH LAND BOILERS

No. 1306, Part I : 1955. Price 3s.—This standard which supersedes the 1946 edition applies to the design and construction of non-ferrous pipework for connecting a land steam boiler to engine, turbine or industrial plant, and to all associated auxiliary pipework, including the individual pipes and pipe fittings forming parts of such installations. It specifies maximum design pressures and temperatures for copper pipes and gun metal castings used in these installations.

The standard is similar and complementary to B.S.806: "Ferrous Pipes and Piping Installations for and in Connection with Land Boilers."

Launches and Trial Trips

CENTURY, cargo ship; built by Hall, Russell and Co., Ltd., for Australian Steamships Pty., Ltd.; length between perpendiculars 335ft. breadth moulded 50ft 3in, depth moulded 26ft 6in, deadweight 5500 tons; four holds, electric winches, four 100kW diesel-driven generators; Ailsa-Doxford opposed piston oil engine, 2300 b.h.p. at 120 r.p.m.—Launch, June 6th.

SAMUEL UGELSTAD, oil tanker; built by the Furness Shipbuilding Company, Ltd., for S. Ugelstads Rederi A/S., Norway; length overall 661ft 7in,, length between perpendiculars 630ft, breadth moulded 87ft, depth moulded 45ft 6in, draught summer freeboard 34ft 2in, deadweight 31,840 tons; thirty oil compartments, heating coils, one main cargo pump room, four 3320 gallons per minute turbine-driven centrifugal cargo oil pumps, four 150 tons per hour vertical duplex reciprocating steam stripping pumps, 13¼in bore cargo main, 12in bore tank suctions; two 500kW turbine-driven, 450V, 3-phase, 60 cycles, alternators, one 100kW diesel-driven alternator; one set of Richardsons Westgarth double reduction geared turbines, 12,500 normal s.h.p. at 105 propeller r.p.m., 13,750 maximum s.h.p. at 108 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by two Foster-Wheeler "D" pattern boilers.—Trial, June 7th.

ALMERIAN, cargo liner; built by the Caledon Shipbuilding and Engineering Company, Ltd., for the Ellerman and Bucknall Lines, Ltd.; length overall 377ft, breadth moulded 53ft, depth moulded to shelter deck 32ft 9in, deadweight 5400 tons, speed 13½ knots; five cargo holds, one 35-ton, two 10-ton, eight 7-ton and two 5-ton derricks, steam winches, one 33kW and two 25kW steam-driven generators; one triple expansion steam engine combined with a Bauer Wach exhaust turbine, 3300 i.h.p. at 92 r.p.m. —Launch, June 8.

CRYSTAL JEWEL, cargo ship; built by Smith's Dock Company, Ltd., for The Sugar Line, Ltd.; length between perpendiculars 430ft, breadth moulded 61ft, depth moulded to upper deck 37ft 3in, deadweight 9740 tons on 24ft 6in draught, service speed 12¼ knots; five main holds, two longitudinal bulkheads, wing spaces for grain or water ballast, two 10-ton derricks at each hold, steam winches; two 75kW diesel-driven generators, one 20kW steam-driven generator; Hawthorn-Doxford two-stroke oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m.—Launch, June 8th.

BADAGRY PALM, cargo liner; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for the Palm Line, Ltd.; length between perpendiculars 415ft, breadth moulded 58ft, depth moulded to shelter deck 35ft; five cargo holds, one 75-ton, six 10-ton and ten 5-ton derricks, electric winches, three 250kW diesel-driven generators; Swan, Hunter-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4500 b.h.p. at 118 r.p.m.—Launch, June 11th.

LONDON VALOUR, oil tanker; built by the Furness Shipbuilding Company, Ltd., for London and Overseas Freighters, Ltd.; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,800 tons on 32ft 4in summer draught, designed trial speed 14¼ knots; twenty-seven oil compartments, one main cargo oil pump room, three 1000 tons per hour turbine-driven centrifugal pumps, three 150 tons per hour steam vertical stripping pumps; two 325kW turbine-driven generators, one 75kW diesel-driven generator; one set of Richardsons Westgarth double reduction geared turbines, 7300 normal s.h.p. at 100 propeller r.p.m., 8200 maximum s.h.p. at 104 propeller r.p.m., two Foster-Wheeler "D" water-tube boilers supply steam at 450 lb per square inch and 750 deg. Fah.—Launch, June 12th.

Catalogues and Brochures

PETROCARBON DEVELOPMENTS, Ltd., 17, Stratton Street, London, W.1.—Illustrated folder giving details of the engineering and consulting services offered for the chemical and petroleum industries.

RANSOMES AND RAPIER, Ltd., Waterside Works, Ipswich—Leaflet dealing with "Rapier" "8" and "10" super-mobile cranes for handling cargo, giving details of their construction and application.

BLAW-KNOX, Ltd., 90/94, Brompton Road, London, S.W.3.—Publication No. 231/1, dealing with "BK-Fifty" lifting and grabbing cranes, giving details of their specification and construction.

BIRLEC, Ltd., Tyburn Road, Erdington, Birmingham, 24.—Folder giving details of a mains frequency coreless induction melting furnace used for melting and alloying ferrous and non-ferrous metals.

DAVIDSON AND CO., Ltd., Sirocco Engineering Works, Belfast, Northern Ireland.—Illustrated booklet giving the history and development of "Sirocco" fan products, used in practically every field of industry.

FLEMING SAFETY GOGGLES (Division of J. and R. Fleming, Ltd.), P.O. Box 110, 146, Clerkenwell Road, London, E.C.1.—Catalogue No. 156, illustrating a range of safety goggles developed to aid and protect vision.

BRITISH ROPES, Ltd., Doncaster.—Booklet describing som of the products of this company and applications in mining, engineering, building construction, shipping, fishing, recreation, agriculture, and the home.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

CHEMICAL SOCIETY

Mon. to Thurs., July 16th to 19th.—The University College o North Staffordshire, Keele, Staffordshire, Symposium on "Chemisorption."

INCORPORATED PLANT ENGINEERS

To-day, June 29th.—BIRMINGHAM BRANCH: Imperial Hotel, Birmingham, "Spring Design and the Plant Engineer," A. A. D. Brown, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., July 17th.—LONDON BRANCH: Works visit to Lafarge Aluminous Cement Company, Ltd., West Thurrock, Essex, 10.15 a.m. (Westminster Pier).

INSTITUTE OF PHYSICS

Wed. to Sat., July 11th to 14th.—NON-DESTRUCTIVE TESTING GROUP: H. H. Wills Physical Laboratory, Bristol, Summer Meeting, "Physics of Some New Aspects of Non-Destructive Testing."

INSTITUTIONS OF CIVIL, MECHANICAL AND ELECTRICAL ENGINEERS

Sat., July 14th.—MIDLAND GRADUATE AND STUDENT SECTIONS: Joint Summer Visit to Claerwen Dam, Wales, 9 a.m. (Civic Centre, Broad Street, Birmingham).

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, June 29th.—Summer Meeting, Birmingham.
Sat., July 28th.—LONDON GRADUATE AND STUDENT SECTION: Summer Outing, 1956. Visit to the College of Aeronautics, Cranfield, combined with a visit to Woburn Abbey, 8.30 a.m. (Savoy Place, W.C.2).

INTERNATIONAL MACHINE TOOL EXHIBITION, 1956

To-day, June 29th, to Fri., July 6th.—Olympia, London, 9.30 a.m. to 6 p.m.

END OF VOLUME 201

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THE ENGINEER

ESTABLISHED 1856

Vol. 201 No. 5240

JUNE 29, 1956

28, Essex Street, Strand, London, W.C.2.

Telephone : CENtral 6565 Telegrams : Engineer Newspaper, Estrand, London

Published every Friday Registered as a Newspaper

PRINCIPAL CONTENTS

(Complete contents on page 743)

Technological Education 743

International Machine Tool Exhibition.—No. II ... 759

Steel Works Locomotives—Diesel or Steam ? ... 746
(M. D. J. BRISBY and J. H. TURNBULL)

Fifth World Power Conference—No. II 749

High-Voltage Power Systems—No. III 775

Antibiotic Production Plant 779

Royal Show at Newcastle upon Tyne—No. I ... 752

Measurement and Analysis of Industrial Noise ... 785

NOTICE TO READERS
All letters intended for insertion in " The Engineer " or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts ; correspondents are therefore requested to keep copies.

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INDEX TO ADVERTISERS—PAGE 163

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Application forms may be obtained from the Director of Education (S/J), County Education Office, Castle Street, Worcester, on receipt of stamped, addressed, foolscap envelope (L.65). E6674

PUBLIC APPOINTMENTS

NORTHAMPTON POLYTECHNIC
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CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

APPOINTMENTS

Applications are invited for appointments in the Civil and Mechanical Engineering Department, for teaching in Degree and Higher National Certificate courses, as follows:—

(1) LECTURER IN CIVIL ENGINEERING subjects, preferably including soil mechanics and/or surveying.

(2) LECTURER IN MECHANICAL ENGINEERING subjects, preferably including applied thermodynamics.

The appointments will be made from 1st September, 1956, or as soon as possible thereafter.

Salary: present scale £1001 by £25 to £1113, revised scale, £1236 by £30 to £1398 from 1st October is now awaiting confirmation.

Further particulars and forms of application are obtainable from the Secretary, to whom applications should be sent by 14th July.

J. E. RICHARDSON, Ph.D., B.Eng., M.I.E.E., A.M.I.Mech.E., Principal.
E6670

UNIVERSITY COLLEGE OF SWANSEA

APPOINTMENTS

Applications are invited for either an ASSISTANT LECTURESHIP or a LECTURESHIP IN ELECTRICAL ENGINEERING. It is desirable but not essential that candidates' interest be in one of the fields: transistor circuitry; control systems, which can be large power speed control apparatus; or aerials.

Salaries: Assistant Lectureship, not less than £550 per annum; Lectureship, £650 by £50 to £1150 per annum.

Commencing salary in each case will be at a point on the appropriate scale, according to age, qualifications and experience. Membership of the F.S.S.U. and children's allowance scheme.

Further particulars may be obtained from the Registrar, University College, Singleton Park, Swansea, to whom applications (six copies) must be sent by July 16th, 1956. E6401

COALVILLE MINING AND TECHNICAL COLLEGE

TEACHING APPOINTMENTS

Required, for September, 1956:

(1) ASSISTANT TEACHER, with graduate or equivalent qualifications, to take charge of new full-time engineering apprenticeship courses for National Coal Board employees. (Standard—up to H.N.C. in Mechanical Engineering.) Salary—Burnham Further Education Scale for Assistants, Grade B.

(2) TWO ASSISTANT TEACHERS, to teach one or both of the following subjects:—general engineering, engineering workshop practice. Salary—Burnham Further Education Scale for Assistants, Grade A.

N.B.—Proposed new salary scales under Burnham Further Education Report are as follows:—

Assistants, Grade A, £475–£900 per annum;
Assistants, Grade B, £650–£1025 per annum.

Applications (no forms), stating age, qualifications and experience, with two recent testimonials and the names of three referees, should be forwarded within fourteen days of the issue of this paper, to the Principal, Mining and Technical College, Coalville, Leicestershire. E6688

LONDON COUNTY COUNCIL

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South East London Technical College, September, 1956. VISITING LECTURERS. H.N. Certificate in Mechanical and Production Engineering. (i) Heat Engines (Internal Combustion Engines, A.1); (ii) Theory of Machines or Strength of Materials, A.1 and A.2; (iii) Applied Mechanics, A.1; (iv) Metrology, A.2. Evenings, 6.45 to 9.15. Pay 56s. per evening. O.N. Certificate in Mechanical Engineering. (i) Applied Mechanics, S.3; (ii) Mathematics, S.3; (iii) Workshop Technology, S.3. 6.45 to 9.15 p.m. 45s. per evening.—Applications from Secretary at College, Lewisham Way, S.E.4, to be returned as soon as possible. (1199.) E6667

WARRINGTON EDUCATION COMMITTEE

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APPOINTMENTS

Applications are invited for the following full-time appointments in the Engineering Department, which are new posts created by expansion in the work of the College:—

ASSISTANT, GRADE A, to teach Mechanical Engineering subjects in the National Certificate courses.

ASSISTANT, GRADE A, to teach Mechanical Engineering subjects, mainly in the Machine Shop Engineering courses.

Application forms and further particulars may be obtained from the Chief Education Officer, Education Office, Sankey Street, Warrington, upon receipt of a stamped, addressed, foolscap envelope, and should be returned as soon as possible. E6689

PUBLIC APPOINTMENTS

BRISTOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY

Principal: G. H. MOORE, M.Sc., F.P.S., F.R.I.C.

APPOINTMENTS

Applications are invited for the following posts available from 1st September next :—

(a) LECTURER, to teach Strength of Materials to National Certificate and National Diploma courses. Ability to teach Theory of Structures and/or other Mechanical or Aeronautical Engineering subjects an advantage.

(b) GRADE B ASSISTANTS (2), to teach Mechanical or Aeronautical Engineering subjects in National Certificate and National Diploma Courses.

(c) GRADE B ASSISTANT, to teach Mathematics in Mechanical and Electrical National Certificate and National Diploma Courses.

(d) GRADE B ASSISTANTS (2), to teach Technology, Practice and ancillary subjects in at least one of the following :—

(i) City and Guilds Machine Shop Engineering.
(ii) Press and Sheet Metal Work.
(iii) Welding, Gas and Electric.
(iv) Patternmaking and Foundry Work.

To a suitably qualified person more advanced work in Higher National Production Courses will be available.

(e) GRADE B ASSISTANT, to teach Electrical Engineering subjects in National Certificate and National Diploma Courses and in City and Guilds courses.

(f) GRADE A ASSISTANT, to teach mainly Electrical Trade subjects, including Electrical Installation. Ability to assist with Radio and Communications courses an advantage.

Burnham Technical scale salaries for all posts at present as follows :—

Lecturer, £965 by £25 to £1065 per annum.
Grade B, £525 by £25 to £820 per annum.
Grade A, £450 by £18 to £725 per annum.

These salaries are under review and subject to confirmation, the following are recommended from 1st October next :—

Lecturer, £1200 by £30 to £1350 per annum.
Grade B, £650 by £25 to £1025 per annum.
Grade A, £475 by £25 to £900 per annum.

Grade A and B Assistants receive additions for degree and training and increments for approved industrial experience.

Application forms and further particulars from the Registrar, College of Technology, Unity Street, Bristol, 1.

G. H. SYLVESTER,
Chief Education Officer.

E6710

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF FLUID MECHANICS

LECTURER

Applications are invited for the post of LECTURER in the Department of Fluid Mechanics. Applicants should have had training or experience in one of the following fields : (a) Hydraulics ; (b) Aerodynamics ; or (c) Hydrodynamics. The initial salary will be within the range £650–£1350 per annum, according to qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 23rd July, 1956, by the undersigned, from whom further particulars of the conditions of appointment may be obtained.

STANLEY DUMBELL,
Registrar.

E6523

ADMIRALTY

BRITANNIA R.N. COLLEGE, DARTMOUTH

LECTURER OR SENIOR LECTURER

The Civil Service Commissioners invite applications from men for two pensionable posts as LECTURER or SENIOR LECTURER—one in Mathematics, and one in Physics and Mechanics. For one post a qualification or experience in art teaching also desirable. Posts to be taken up by January, 1957. Age at least 23 on 1st July, 1956. Appointment to the senior grade will depend on academic qualifications and teaching experience. Candidates must have an appropriate Honours degree. Teaching experience desirable.

Inclusive salary scales : Lecturers, £509–£948 ; Senior Lecturers, £1008–£1320. Starting salary above minimum in appropriate cases. Pay and conditions of service are under review.

Full particulars and application forms from the Secretary, Civil Service Commission, 6, Burlington Gardens, London, W.1, quoting No. 4607/56/9. Completed forms should be returned by 16th July, 1956.

E6698

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER

Applications are invited for the post of LECTURER in the Department of Mechanical Engineering. The initial salary will be within the range £650–£1350 per annum, according to qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 28th July, 1956, by the undersigned, from whom further particulars of the conditions of appointment may be obtained.

STANLEY DUMBELL,
Registrar.

E6628

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

Principal : G. E. WATTS, M.A., Ph.D. (Cantab), B.Sc. (Lond.), F.R.I.C.

GRADUATE LECTURER OR ASSISTANT LECTURER

Required, GRADUATE LECTURER or ASSISTANT LECTURER in CIVIL ENGINEERING to teach Civil Engineering subjects to Degree and Professional levels, with special reference to Hydraulics. Corporate Membership of the Institution of Civil Engineers an advantage. Previous teaching and industrial or research experience desirable. Revised salary scales (subject to confirmation) :

Lecturer, £1200 by £30 to £1350 per annum.

Assistant Lecturer, £725 by £25 to £1100 per annum, with allowances for training and increments for approved industrial experience.

Further particulars and forms of application from the undersigned, to be returned to the Principal, Brighton Technical College, Brighton, 7, as soon as possible.

W. G. STONE,
Director of Education.

54, Old Steine,
Brighton.

E6711

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF CIVIL ENGINEERING

SENIOR RESEARCH ASSISTANTS

Applications are invited for appointments as SENIOR RESEARCH ASSISTANTS. Salary within the scale £650 by £50 to £1050, plus family allowance of £50 per annum for each child and superannuation benefits. Applicants should be graduates with practical experience. Conditions of appointment and form of application from the undersigned.

H. PICKBOURNE,
Registrar.

E6701

ESSEX

THURROCK TECHNICAL COLLEGE, GRAYS

ASSISTANT, GRADE B

ASSISTANT, GRADE B, required in September to take charge of new welding shop and to develop this subject. Initially, the person appointed will also be required to assist materially with City and Guilds Machine Shop Engineering courses.

Salary (under review) £525 by £25 to £820 p.a., with additions for training and approved professional qualifications. Increments allowed for teaching, war/national service and approved industrial experience.

Details and forms (stamped, addressed, foolscap envelope) from the Clerk to the Governors, Divisional Education Office, Upminster Court, Hall Lane, Upminster.

E6707

BRITISH MEMORIAL FUND

BRITISH MEMORIAL FELLOWSHIPS

Applications are invited for a FELLOWSHIP IN CHEMICAL ENGINEERING, carrying a grant of £1000 (Australian), which is intended to cover the cost of transit by sea to and from Melbourne and all expenses for a period of approximately ten months, during which period the Fellow will study and undertake research based in the State of Victoria, Australia.

The Fellowship is available to any well-qualified scientist or engineer working on any aspect of chemical engineering, but preference will be given where Australian facilities or conditions will promote the candidate's studies or widen his interests.

Applicants should be under thirty-five years of age.

All particulars are available from Colonel the Honourable W. W. Leggatt, Agent-General for Victoria, and Chairman of the British Memorial Fund Committee, Victoria House, Strand, London, W.C.2.

E6694

AIR MINISTRY

ROYAL AIR FORCE AIRFIELD CONSTRUCTION BRANCH

SHORT SERVICE COMMISSIONS

Civil, Mechanical and Electrical Engineers are invited to apply for SHORT SERVICE COMMISSIONS of 3, 4, 5 or 6 years' duration in the Royal Air Force Airfield Construction Branch, followed by 4 years on the R.A.F. Reserve of Officers. The period of active service can be extended. On leaving the R.A.F. officers will be eligible for appointments in the Air Ministry Directorate General of Works. Civil Engineers must have had training in design, experience in construction, and should normally have passed Parts I and II of the Associated Membership Examination of the Institution of Civil Engineers, or have an Engineering Degree or equivalent. Mechanical and Electrical Engineers must have served an apprenticeship, have had practical experience and should normally hold an Engineering Degree or be Graduates or Corporate Members of the Institution of Mechanical Engineers or the Institution of Electrical Engineers.—Further particulars and application forms obtainable from Air Ministry, A.R.1, Adastral House (A.C.3), Theobalds Road, London, W.C.1.

E6684

PUBLIC APPOINTMENTS

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

REACTOR DIVISION

(INSTRUMENTATION)

APPOINTMENT

Atomic Energy Research Establishment, Harwell, has a vacancy in the Reactor Division (Instrumentation), in the Technical Class, Grade I, for work involving Specification, Procurement and Installation testing of equipment in new Reactor projects, and necessitating close liaison with other Engineering and Scientific Division.

Applicants should have served a recognised engineering apprenticeship or have had equivalent training. Experience in one or more of the following fields desirable :—

(i) Process Instrumentation.
(ii) P.O. Telephone Practice.
(iii) Electro-mechanical equipment of the type used in remote control systems.

A good basic knowledge of electronics is desirable. Possession of H.N.C. (Electrical) would be an advantage.

Salary : £925–£1149 p.a.

Contributory pension scheme ; five-day week ; excellent working conditions and generous leave allowances.

Married officers living outside the Establishment's transport area will be eligible for housing under Authority arrangements, or, alternatively, substantial assistance towards legal expenses incurred in house purchase will be available.

Send postcard for application, which must be returned by 3rd July, 1956, to Establishment Officer, A.E.R.E., Harwell, Nr. Didcot, Berks, quoting reference 568/25.

E6646

FEDERATION OF RHODESIA AND NYASALAND

MINISTRY OF AGRICULTURE

DEPARTMENT OF CONSERVATION AND EXTENSION

VACANCY :
CONSERVATION ENGINEER

Applicants must hold a Degree or an approved equivalent qualification in Civil Engineering. Experience in soil and/or water conservation work, hydrology, and particularly land drainage, will be a recommendation.

Duties will include fundamental as well as applied research on various aspects of soil and water conservation, erosion control and hydrology. In connection with hydrology the work will deal essentially with problems of land drainage.

Starting salary £800–£1100, depending on qualifications and experience on a scale rising to £1600. Promotion to senior posts possible and will depend on vacancies and efficiency.

Application forms and further details from Federal Public Service Attache, Rhodesia House, 429, Strand, London, W.C.2. Closing date 14th July.

E6666

NATIONAL COAL BOARD

MECHANISATION BRANCH

DEMONSTRATING ENGINEER (TUNNELLING)

DEMONSTRATING ENGINEER (TUNNELLING) required in Mechanisation Branch of N.C.B.'s H.Q. Production Department in London. The successful applicant will spend considerable time in the coalfields on duties which include giving practical help in the organisation of the Board's demonstration tunnel, and the instruction of divisional tunnelling crews in the application of techniques developed in the demonstration tunnel. Considerable experience is required in the practical aspects of high speed tunnel driving with intimate knowledge of modern machines and equipment. A recognised mining or engineering qualification is desirable but not essential. Appointment (superannuable) according to qualifications and experience, within inclusive range £962–£1178.

Write, with full particulars of age, education, qualifications and experience, to National Coal Board, Staff Dept., Hobart House, London, S.W.1, marking envelope SS/329, before 16th July, 1956.

E6722

THE BRITISH IRON & STEEL RESEARCH ASSOCIATION

METALLURGIST OR ENGINEER

METALLURGIST or ENGINEER required as Head of the Coil Spring Federation Research Laboratory in Sheffield. Applicants should be capable of taking charge of laboratory research and development work concerned with springs, their manufacture, testing and use. They should also be familiar with materials, both steel and non-ferrous alloys, used in spring manufacture. Honours Degree in Metallurgy or Engineering, with experience of academic and applied research and authorship essential. Starting salary in the range £1200 to £1700 p.a., according to age, qualifications and experience. Post is superannuated under the F.S.S.U.—Written applications only, quoting "C.S.F.1," to Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1.

E6690

PUBLIC APPOINTMENTS

NORTH EAST DERBYSHIRE JOINT WATER COMMITTEE

ASSISTANT ENGINEER

Applications are invited for the above appointment at a salary in accordance with A.P.T. IV–V (£710–£970). The commencing salary will be determined in accordance with the successful applicant's qualifications and experience.

The appointment will be subject to :

(a) The National Joint Council's Scheme of Conditions of Service ;

(b) The Local Government Superannuation Act, 1937, for which purpose the successful candidate will be required to pass a medical examination, and

(c) To one month's notice on either side.

Applicants must be Corporate Members of the Institution of Civil Engineers and they should have had previous experience in the design and construction of service reservoirs, treatment plant and pumping stations.

The Committee will assist the successful applicant in obtaining housing accommodation.

A car allowance will be paid for a car up to 8 H.P. in accordance with the National Scales.

Applications, stating age, present and previous appointments, experience, qualifications, &c., together with the names of two referees, should be submitted to the undersigned not later than Monday, 23rd July, 1956.

H. O. HAWKINS,
Clerk.

Rural Council House,
Saltergate,
Chesterfield,
19th June, 1956.

E6662

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

ALDERMASTON, BERKS

ENGINEER (BASIC GRADE)

ENGINEER (Basic Grade) required by the Atomic Weapons Research Establishment, Aldermaston, Berks, to assist senior staff engaged on planning of new buildings, including mechanical and electrical installations, site services and plant.

Applicants should have served a recognised apprenticeship and possess Associate Membership of the Institutions of Civil, Electrical or Mechanical Engineers or have exempting qualifications.

Experience in the field of heating and ventilating, acceptance tests of mechanical and electrical installations and works services associated with buildings containing explosives is desirable.

Salary : £766 at age 25, to £1050 at age 34 or over on entry, rising to £1199 p.a. Contributory superannuation scheme. Married officers now living outside the Establishment's transport area will be eligible for housing on one of the Authority's estates. Alternatively, assistance towards legal expenses incurred in house purchase may be available ; until housed a lodging allowance may be payable.

Requests for application forms by postcard to the Senior Recruitment Officer at the above address, not later than 9th July, 1956. Please quote ref. 1188/25.

E6644

CIVIL SERVICE COMMISSION

ENGINEERS

ENGINEERS : (a), Civil, (b) Structural, (c) Sanitary. The Civil Service Commissioners invite applications for pensionable posts.

Age at least 25 and under 35 on 1st January, 1956, with extension for regular Forces' service and appropriate civil service.

Candidates must (i) be Corporate Members of an appropriate Professional Institution, and, for some posts, have qualified in certain subjects, or (ii) have passed, or been exempted from, examinations necessary for obtaining Associate Membership ; such candidates would be expected to qualify under (i) in due course. Professional experience expected.

London salary scale : (men) £741 (at age 25) to £1160. Starting salary according to age up to £1018 at 34 or over. Lower rates outside London. Prospects of promotion to higher grades on salary scales £1160–£1500 and £1555–£1760 and above. Women's salaries lower, but being improved under equal pay scheme.

Salaries and conditions of service are under review.

Further particulars and application forms from Civil Service Commission, Scientific Branch, 30, Old Burlington Street, London, W.1, quoting No. S64–66/56. Completed forms should be returned as soon as possible ; applications for posts (b) and (c) should be returned not later than 30th September, 1956.

E6699

MINISTRY OF HEALTH

GOLD COAST

MAINTENANCE ENGINEER

MAINTENANCE ENGINEER required by Ministry of Health, Gold Coast, for two tours of 18 to 24 months in first instance, with prospect of renewal of contract. Consolidated salary in scale £1710, rising to £1810 a year. Gratuity at rate of £150 a year. Outfit allowance £30. Free passages, liberal leave on full salary. Duties will include maintenance of a hospital's mechanical and electrical equipment and installations, including the structure and furnishings, sewage systems and water supply. Candidates must have had considerable experience in hospital engineering in supervisory capacity.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2A/40812/EH.

E6697

Classified Advts. continued on page 4

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY AUTHORITY

STATION DEVELOPMENT SUB-BRANCH

ENGINEERS

Central Electricity Authority require ENGINEERS in the Station Development Sub-Branch at Bankside House, London, S.E.1. The duties include the planning of new generating capacity throughout the country, the co-ordination and direction of investigations into sites for orthodox and nuclear power stations and negotiations for statutory and other consents. Candidates should possess an Honours Degree or the requisite qualifications for Corporate Membership of the Institution of Mechanical, Electrical or Civil Engineers. A sound engineering or scientific background is essential and experience of one or more of the problems arising in the siting of power stations, i.e. geology and ground exploration, fuel supply, use of rivers and the effects of heating, discharge and dispersal of chimney emissions and questions of town and country planning would be an advantage. Starting salaries will depend upon qualifications and experience.

Senior Assistant Engineer : £1225–£1575 p.a.
Second Assistant Engineer : £1045–£1395 p.a.
Third Assistant Engineer : £977–£1190 p.a.
Fourth Assistant Engineer : £772–£956 p.a.

Applications, on Form AE.6, obtainable from D. Moffat, Director of Establishments, Winsley Street, W.1, to be completed and returned by 12th July, 1956.
Quote Ref. AE/838. E6693

TRINITY HOUSE, LONDON

ENGINEERING ASSISTANT

Applications are invited for an ENGINEERING ASSISTANT (Mechanical) on the staff of the Corporation of Trinity House, the General Lighthouse Authority for England and Wales.

Applicants should be of British nationality, medically fit, and between the ages of 25 and 30 years. They must have served an engineering apprenticeship and be Corporate Members of the Institution of Mechanical Engineers, or have passed Sections A, B and C of the examination for Corporate Membership or hold equivalent qualifications.

Applicants should be capable draughtsmen, experienced in the layout and installation of internal combustion engines, compressors, auxiliary equipment and pipework. The work entails occasional site vists and applicants must be prepared to travel.

The appointment is permanent and pensionable, subject to a probationary period of not less than one year. Salary £765 per annum (at age 25), rising to £1190 per annum. Maximum starting salary £900 per annum (age 30).

Applications to be made to the Secretary, Trinity House, Tower Hill, London, E.C.3, not later than 16th July, 1956, stating age, qualifications, experience, and enclosing testimonials. E6659

COUNTY BOROUGH OF EAST HAM

BOROUGH ENGINEER'S DEPARTMENT

JUNIOR MECHANICAL ENGINEERING ASSISTANT

JUNIOR MECHANICAL ENGINEERING ASSISTANT—Grade II, £595–£675.

London Weighting is paid in addition. Salary in excess of the minimum may be paid, according to qualifications and experience.

A subsistence allowance may be granted over a reasonable period to the person appointed if unable to obtain suitable housing accommodation, necessitating the maintenance of two homes.

Further details and application forms returnable by 13th July, 1956, from the Town Clerk, Town Hall, East Ham, E.6. E6649

PRODUCTION ENGINEERING RESEARCH ASSOCIATION

APPOINTMENTS

Production Engineering Research Association requires the following staff :

GRADUATES (or equivalent) in ENGINEERING, SCIENCE, PHYSICS or METALLURGY, for fundamental and applied research on a wide range of production processes and equipment.

RESEARCH ASSISTANTS—G.C.E., O.N.C., or higher qualifications.

Previous experience not essential ; good prospects of advancement. Status and commencing salary will depend on age, qualifications and experience. Superannuation under F.S.S.U. Applications welcomed from graduates completing national service this year. Send full details to Secretary, P.E.R.A., Melton Mowbray. E6604

SOUTHAMPTON CORPORATION WATERWORKS

CIVIL ENGINEERING ASSISTANT

Southampton Corporation Waterworks require CIVIL ENGINEERING ASSISTANT, age not exceeding 35. Must have passed Parts 1 and 2, Institution of Civil Engineers, or exempting examination. Experience in waterworks advantageous. Salary : A.P.T. "Special Scale" (£690–£840). Conditions of appointment from Joseph Hawksley, M.I.C.E., Waterworks Engineer, Civic Centre, Southampton. Applications by 17th July, 1956. E6553

PUBLIC APPOINTMENTS

GOVERNMENT OF QATAR, PERSIAN GULF

STATE ENGINEER'S OFFICE

APPOINTMENTS

Applications are invited for the following posts under the direction of the State Engineer, Government of Qatar, Doha :—

DESIGN ENGINEER.

Applicants for the post of Design Engineer should be qualified Civil Engineers (Associate Members of the Institution of Civil Engineers or other internationally recognised body), having particular experience of the layout and design of roads (bitumen macadam and reinforced concrete) and reinforced concrete structure, together with a sound working knowledge of the design of water supply, sewerage and sewage disposal schemes. Applicants should be rapid and competent draughtsmen.

The successful applicant will assist in the design of many of the civil engineering works associated with a rapidly expanding town.

ASSISTANT ARCHITECT

Applicants for the post of Assistant Architect should be qualified Architects (Associates of Royal Institute of British Architects or other internationally recognised body), having good general experience of the design of private and public buildings. Applicants should be rapid and competent draughtsmen.

The successful applicant will assist the Government Architect in the design of the many architectural projects associated with a rapidly expanding town.

Salary : For both above appointments will be according to Scale E2. Each starting at Rs.1775 an Arabic month, with annual increments of Rs.75 a month up to Rs.2000, and then by annual increments of Rs.100 per month to a maximum of Rs.2300 per month. (Rs.1775 an Arabic month is equivalent to £1590 Sterling a Gregorian year.)

Gratuity : Payable on the basis of one month's pay for each completed year of service, on completion of contract only.

Probation : Probationary period of six months, during which contract may be terminated at three months' notice by the Government, without stating its reason.

Contract : A five-year contract subject to successful completion of the probationary period. The employee may terminate the contract at three months' notice only after completing one year's service.

Accommodation : Free furnished bachelor accommodation, fuel, light and water. Married accommodation will be provided in accordance with the rules but in no case before successful completion of probationary period.

Leave : Will be earned at the rate of 6 days for each completed month of duty.

Free Travel : On first journey to Qatar, leave not exceeding one return 1st Class air passage in each year and termination for applicant, wife and children up to 18 years of age.

General : The climate is hot for about five months of the year but this is offset by air conditioning in staff houses and offices. Good climate for the rest of the year.

No income tax. Duty car allowance. Free medical and dental treatment.

Applications, endorsed "Design Engineer" or "Assistant Architect," as the case may be, giving full personal particulars, including age, nationality, religion, education, marital status, qualifications, training, past experience and employment, names and addresses of three referees, and latest photograph, should be sent in duplicate to :—

The Adviser to the Government of Qatar, P.O. Box No. 36, Doha, Qatar, Persian Gulf.

A further copy with enclosures similarly endorsed should be sent to :

Messrs. C. Tennant, Sons and Co., Ltd., 4, Copthall Avenue, London, E.C.2. E6556

AIR MINISTRY

MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require MECHANICAL and ELECTRICAL ENGINEERS in Works Directorate for design and supervision of mechanical and electrical services at home and overseas in Assistant Grade, £800 at age 25, rising annually to £1252, but somewhat lower in provinces. Appointments non-pensionable, but with long-term possibilities. Overseas allowance up to £1500 a year. Candidates normally must be natural-born British subjects. Minimum qualifications : (a) University Degree or equivalent Diploma in Electrical and/or Mechanical Engineering with at least two years' apprenticeship ; or (b) Graduate or Corporate Member of I.E.E. with at least three years' apprenticeship ; or (c) Graduate or Corporate Member of I.Mech.E., appreciable electrical engineering experience with at least three years' apprenticeship. Experience, minimum of three years with well-established engineering concern and wide experience in both electrical and mechanical engineering practice.—Application forms, quoting reference D240/5A, from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1. E6022

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

GRADUATE MECHANICAL ENGINEER

GRADUATE MECHANICAL ENGINEER required by the Association for research on the engineering aspects of cutlery production, with emphasis on new machines and processes. Previous experience of cutlery production not essential, but candidates who have had one or two years' practical engineering experience wouldbe preferred. Starting salary within the range £660–£900 p.a., according to age, qualifications and experience. Location of work Sheffield. Post is superannuated under the F.S.S.U.—Written applications only, quoting "C.U.I.," to Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. E6672

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY AUTHORITY

EASTERN DIVISION

CIVIL AND STRUCTURAL DESIGNER-DRAUGHTSMEN

Applications are invited for the following appointments in the Generation (Construction) Department at Divisional Headquarters in North London :—

CIVIL AND STRUCTURAL DESIGNER-DRAUGHTSMEN

Salary N.J.B., Schedule "D," within the range of Grades 4/5, £735 by £20 to £955 per annum, including London weighting.

The commencing salary will depend on experience and qualifications.

The candidates appointed will be required to undertake civil and structural design work, and applicants should have had experience in the design and detailing of reinforced concrete structures for heavy plant, culverts, &c., and structural steelwork as applied to industrial buildings.

Applications, stating age, qualifications and experience should be sent to the Controller, Central Electricity Authority, Eastern Division, Northmet House, Southgate, N.14, by 7th July, 1956.

W. N. C. CLINCH,
E6675 Controller.

THE BRITISH IRON & STEEL RESEARCH ASSOCIATION

RESEARCH ASSISTANT

RESEARCH ASSISTANT required by the Civil and Structural Section of the Plant Engineering Division of the Association in London for interesting and varied research for a basic and expanding industry. Duties will include stress measurements on model and full-scale steelworks structures in the London laboratories and on site, and computing test results. Candidates should have at least an Ordinary National Certificate or equivalent qualifications in Civil or Mechanical Engineering. Time off for further study will be given. Starting salary up to £650 p.a., according to age, qualifications and experience. Five-day week, staff pension scheme.—Written applications only, quoting "C.E.9," to the Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. E6706

KENT COUNTY COUNCIL

BUILDINGS DEPARTMENT

PRINCIPAL ENGINEERING ASSISTANT

Applications are invited for the post of PRINCIPAL ENGINEERING ASSISTANT on the permanent establishment of the Buildings Department at a salary on J.N.C. scale F/G (£1625 by £55 to £2065).

Candidates, who must be Corporate Members of one or more of the appropriate professional bodies should have considerable experience of heating, hot and cold water supply and ventilation systems, together with a good knowledge of electrical installations.

Applications, on forms obtainable from the County Architect, Springfield, Maidstone, should be delivered to him not later than the 18th July, 1956. Canvassing in any form will disqualify.

GERALD BISHOP,
Clerk of the County Council.
County Hall, Maidstone,
11th June, 1956. E6548

NORTH THAMES GAS BOARD

CHEMICAL PRODUCTS WORKS, BECKTON

A SENIOR DRAUGHTSMAN

A SENIOR DRAUGHTSMAN, aged 30–45, is required at the Chemical Products Works, Beckton, E.6. Candidates should have considerable experience in the design and layout of plant from flow diagrams, and in the preparation of schemes and contract specifications, both for development and maintenance work. Starting salary will be within the range £750 to £900 per annum, according to age, qualifications and experience. The successful candidate will be required to join the staff pension scheme.

Applications, giving age and full particulars, to Staff Controller, North Thames Gas Board. 30, Kensington Church Street, W.8, quoting reference 666/324. E6704

HORTHAM-BRENTRY HOSPITAL MANAGEMENT COMMITTEE

SENIOR ENGINEER

Applications invited for post of SENIOR ENGINEER at Brentry Hospital, Westbury-on-Trym, Bristol (mental deficiency : 440 beds).

Duties involved direct responsibility to Superintendent Engineer for maintenance of buildings and engineering services (including steam boiler plant).

Applicants should have completed apprenticeship in mechanical engineering or otherwise acquired practical mechanical engineering training, and should possess appropriate qualifications.

Salary : £585–£705 per annum. Whitley Council conditions of service ; National Health Service Superannuation Scheme.

Applications, with details of age, experience and qualifications, together with names of three referees, to Group Secretary, by not later than 14th July, 1956. E6589

PUBLIC APPOINTMENTS

RHODESIA RAILWAYS

VACANCIES FOR CIVIL ENGINEERS

Vacancies exist for fully qualified CIVIL ENGINEERS, for service in the Chief Engineer's Department of the Rhodesia Railways. Preferably men under the age of 25 years will be considered, but married men not exceeding 30 years of age may apply.

Applicants over 25 years of age should be in possession of a Degree in Civil Engineering and be Corporate Members of the Institution of Civil Engineers.

Applicants under 25 years of age should be in possession of a Degree in Civil Engineering and have passed Parts "1" and "2" of the Institution Examination for Corporate Membership.

The grade of Assistant Engineer has a salary scale between the limits of £850 and £1800 per annum and the commencing salary would be determined in accordance with age and experience. The normal incremental scales between £850 and £1850 per annum mentioned are as follows :—

£850 by £50 to £900
£900 by £100 to £1000
£1000 by £50 to £1300
£1300 by £100 to £1400
£1400 by £50 to £1500
£1500 by £100 to £1800

Vacancies may occur later on for members of the Permanent Staff for the grade of District Engineer by selection, within the scale of £2000 to £2300 per annum, incremental notches being £100 per annum.

Income Tax in the Federation is not unreasonable and at the present time a married man with one child earning £1200 per annum would pay £12.

Membership of the Contributory Pension Fund and Medical Fund is obligatory and the usual rail privileges in respect of travelling concessions, leave, &c., will apply.

Housing is provided for married Engineers who are liable for transfer at moderate rentals. Where no railway housing is provided a Marriage Accommodation Allowance of £72 per annum is paid under certain conditions.

The Rhodesia Railways will bear the full fare from the port of embarkation to the port of disembarkation, subject to the Administration selecting class and type of transport. In the case of a married man, the railways will bear up to a maximum of £70 for his wife and a further total sum of £70 to cover his dependent children under the age of 18 years. In addition, free third-class travel will be provided for himself, wife and family from his home town to port of embarkation, and free first-class travel from the port of disembarkation to Bulawayo, or to place of employment on the Rhodesia Railways.

Applicants should apply to the London Agent, Rhodesia Railways, 241, Salisbury House, London Wall, London, E.C.2, for further particulars and conditions of service. E6

GLANTAWE HOSPITAL MANAGEMENT COMMITTEE

ENGINEERING ASSISTANT

Applications are invited for the post of ENGINEERING ASSISTANT. Salary scale £480 by £20 (7) by £25 (2) to £670 (now under review).

The successful candidate will be responsible to the Superintendent Engineer and will assist in the technical work involved in the maintenance of the engineering plant and buildings at the various General Hospitals, as well as being responsible for the drawing up of plans for engineering and building works of a minor character.

Applicants must have had proper training in mechanical engineering and be qualified in draughtsmanship, and have obtained the Ordinary National Certificate in Mechanical Engineering.

Experience in the design and installation or running of the plant and services in hospitals, or similar institutions, will be an advantage.

The successful candidate, if not a transfer officer, will be required to pass a medical examination and will be subject to the National Health Service Superannuation Regulations.

Applications, stating age, qualifications and experience, together with the names of three referees (two technical), should be forwarded in an envelope endorsed "Engineering Assistant," to reach the undersigned not later than Saturday, 7th July, 19

T. E. JONES,
Group Secretary
Glantawe Hospital Management Committee,
St. Helen's Road,
Swansea. E6

GLANTAWE HOSPITAL MANAGEMENT COMMITTEE

MORRISTON HOSPITAL, SWANSEA

ASSISTANT ENGINEER

Applications are invited for the post of ASSISTANT ENGINEER at the above hospital. Applicants must have served an apprenticeship in mechanical engineering, and should hold an Ordinary National Certificate in Mechanical Engineering, which include heat and heat engines as a subject, and preferably have an endorsement in the Principles of Electrical

The salary will be on the scale £525 by £20 (1) to £25 (4) to £645 per annum. The post is subject to the National Health Superannuation Scheme and to the conditions of service as prescribed by the Hospital Services Whitley Council for Professional and Technical Staffs.

Applications, stating age, qualifications and experience, together with copies of three recent testimonials, should be forwarded to the Secretary, Glantawe Hospital Management Committee, St. Helen's Road, Swansea, in an envelope endorsed "Assistant Engineer," to be received not later than Saturday, 7th July, 1956. E6

TENDERS

GOVERNMENT OF IRAQ

DEVELOPMENT BOARD AND MINISTRY OF DEVELOPMENT, BAGHDAD

DIBIS POWER STATION CONTRACT NO. 4

CIVIL ENGINEERING WORKS

The Development Board and the Ministry of Development of the Government of Iraq invite TENDERS from experienced Civil Engineering firms for the CONSTRUCTION of the CIVIL WORKS for the Dibis Power Station, Iraq.

Tender documents may be inspected on and after July 2nd, 1956, until August 27th, 1956, at the following addresses :—

(1) Directorate General of Legal Affairs and Contracts, Ministry of Development, Development Board, Baghdad.

(2) Embassies of Iraq, in Washington, London, and Paris.

(3) Royal Legations of Iraq in Bonn, Brussels, and Rome.

(4) Consul Honoraire of Iraq, in Stockholm, and Egyptian Legations in Bern and The Hague.

(5) At the office of the Consulting Engineers, Messrs. Electrobel-Traction and Electricite, 1, Place du Trone, Brussels.

Firms desiring to Tender may obtain two sets of contract documents, each set consists of Volume 1, 2A, 3B, 3C, 3D and 4 for Tender, on and after July 2nd, 1956, until August 27th, 1956, from either the Directorate General of Legal Affairs and Contracts at the Development Board offices, Baghdad, or Messrs. Electrobel-Traction and Electricite, 1, Place du Trone, Brussels, Belgium, or the above-mentioned Embassies and Legations on payment of forty Iraqi dinars or the equivalent of same. This charge will not be returned to the Tenderers.

All Tender documents are to be submitted in English and they must be accompanied by a deposit of ID.15,000 (Fifteen Thousand Iraqi Dinars), which must be paid in cash to the Directorate General of Accounts of the Ministry of Development, and the receipt issued for such payment must be attached to the Tender documents. Such cash deposit may be replaced by a Bank Guarantee from or through an approved bank in Iraq.

Tenders must be submitted in sealed envelope, marked on the outside "DIBIS Power Station—Tender for Civil Engineering Works." They must be delivered at the Ministry of Development on or before 12 noon, local time, on September 24th, 1956. If sent by post, the Tenders shall be registered, and Tenderers must assure themselves of delivery to the Board in the due time. A letter of capacity, method of procedure, articles of association, are to be submitted with the Tender at the same time.

Tenders not submitted within the time specified or not accompanied by a receipt of the deposit or Bank Guarantee shall be neglected.

The attention of Tenderers is called to the fact that early completion of the project is desired, and therefore an early completion date will be considered an important factor in the selection of the successful Tenderer.

The Development Board does not bind itself to accept the lowest or any Tender.

MINISTER OF DEVELOPMENT
E.C. E6725

GOVERNMENT OF IRAQ

DEVELOPMENT BOARD AND MINISTRY OF DEVELOPMENT

IRAQ HOUSING PROGRAMME

Pre-announcement of coming TENDERS for HOUSING PROJECTS.

(1) The Development Board and the Ministry of Development of the Government of Iraq would like to bring to the notice of contracting firms interested in housing constructions that several Tenders will be advertised for such constructions.

(2) Advertising will start from May, 1956. Iraq and/or foreign contractors may participate.

(3) The works will include construction of houses of different types and construction of community facilities, viz. pedestrian and vehicular roads, water supply, sewerage and, in certain cases, electricity supply. (4) The tendering period will vary between 9 and 13 weeks according to the size of each contract.

(5) Tenders will only be accepted from persons or firms who have had previous experience in works of similar nature and magnitude. To this end, participating contractors will be requested to submit, together with their Tenders, a letter of capacity and Articles of Association.

(6) A schedule of the coming Tenders is the following :—

(a) Contract SPA/6 (1956) : Western Baghdad Development, Sector 4, Experimental Housing Scheme for the Construction of 200 Two-Storey Houses. Architectural drawings will be requested to suggest the system and method of construction.

(b) Contract SPA/7 (1956) : Construction of 200 Houses and Community Facilities in Mosul.

(c) Contract SPA/8 (1956) : Construction of 200 Houses and Community Facilities in Basrah.

(d) Contract SPA/9 (1956) : Western Baghdad Development, Sectors No. 8 and 13. Construction of 2400 Houses and Community Facilities.

(e) Contract SPA/10 (1956) : Construction of 200 Houses and Community Facilities at Kirkuk.

(f) Contract SPA/11 (1956) : Construction of 200 Houses and Community Facilities near Mosul at Mosul Cement Factory.

(g) Contract SPA/12 (1956) : Construction of 200 houses in Mosul for Mosul Sugar Plant.

(7) Further details regarding these coming Tenders may be obtained from the Ministry of Development, Directorate General, Technical Section 5, Southgate, Baghdad, Iraq, or from the Consulting Engineers at the following addresses :—

(a) Doxiadis Associates, Consulting Engineers, 10, Venizelon Street, Athens, Greece.

(b) Doxiadis Associates, Consulting Engineers, 2/2, S3, Sa'adoon, Baghdad, Iraq.

THE MINISTER OF DEVELOPMENT.
E6460

TENDERS

MID AND SOUTH EAST CHESHIRE WATER BOARD

ELECTRICAL EQUIPMENT

The Board invite TENDERS for the SUPPLY and INSTALLATION of VERTICAL SPINDLE, ELECTRICALLY - DRIVEN, CENTRIFUGAL PUMPS and ANCILLARY EQUIPMENT as follows :—

CONTRACT No. H.2

Two No. 75 H.P. Pumps ; Three No. 65 H.P. Pumps and Three No. 7 H.P. Pumps, all to be installed at a Water Supply Treatment Works at Hurleston, near Nantwich, Cheshire.

CONTRACT No. H.3.

Three No. 30 H.P. Pumps and Two No. 15 H.P. Pumps, to be installed in a reservoir intake tower at Hurleston.

CONTRACT No. F.1

Three No. 80 H.P. Pumps, to be installed in a river intake station on the banks of the River Dee at Fron, Denbighshire, approximately 4 miles east of Llangollen.

General conditions of contract, specification and drawings may be obtained from Mr. Delwyn G. Davies, B.Sc., M.I.C.E., M.I.M.E., Engineer and Manager to the Board, on payment of a deposit of £2 in respect of each contract, which will be refundable upon receipt of a bona-fide Tender and return of contract documents. Deposit cheques should be made payable to the Mid and South East Cheshire Water Board.

Tenders to be returned in accordance with instructions contained in the contract documents and must be received by the undersigned not later than 10 a.m. on Tuesday, the 14th August, 1956.

The Board does not bind itself to accept the lowest or any Tender.

C. J. WALKER,
Clerk to the Board.
Mid and South East Cheshire Water Board,
P.O. Box No. 4,
Weaverham Grange,
Hartford,
Northwich,
Cheshire. E6724

EDUCATIONAL

FREE ! Brochure giving details of Courses in Mechanical and Production Engineering Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other Professional Examinations. —E.M.I. Institutes, Dept. E.30, London, W.4 (associated with H.M.V.). E708 E

A.M.I.MECH.E., B.SC., City and Guilds, &c., Guaranteed Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 E

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E.
A.M.I.Chem.E., A.M.I.M.I.,
A.F.R.Ae.S., C & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus, FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29 WRIGHT'S LANE, LONDON, W.8.
E102 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A LARGE and progressive company in the heavy chemical manufacturing field requires ASSISTANT ENGINEERS for supervision of maintenance. The positions offer good prospects of advancement in a rapidly expanding concern. Applications are invited from men in the age group 30–45 years, who have practical experience, preferably on plant maintenance or construction, and technical qualifications to not less than H.N.C. or equivalent. Personality, qualities of leadership and managerial ability are important. The company operates in a pleasant semi-rural area and conditions of employment bear comparison. Apply in confidence, quoting ref. G.48, BOX No. E6634, "The Engineer." A

A MANAGER/ENGINEER is required for bulking installation in West Africa handling palm oil. Candidates must be of good education with very good administrative and organising abilities, experience in plant maintenance and control ; preferably A.M.I.Mech.E. or equivalent. Age 26 to 33. The post is one of responsibility and involves contact with local authorities, also control of African staff and their training when required. Practical experience should include operation and maintenance of steam boilers, engines and pumping plant, and preferably of centrifuges, diesel engines and electrical equipment. Knowledge of chemistry would be an advantage. Commencing salary will be in accordance with qualifications and experience, but not less than £1500 per annum. In addition, there are family allowances, free furnished accommodation, and free medical attention in Africa. First-class passages provided. Tours in West Africa would be about 21 months each, followed by leave on full pay. There is an initial kit allowance of £75. Contributory pension fund. Apply, giving full details of experience. —BOX No. E6652, "The Engineer." A

SITUATIONS VACANT

A LARGE INDUSTRIAL COMPANY in the South of England is engaged on a programme of expansion running into several million pounds. The programme not only includes extensions to existing plants, but provides also for increased activity into relatively novel fields. The individual projects vary in character and involve all types of engineering from light precision machine work to heavy process equipment, and include all the planning, layout and procurement associated with the design and erection of large manufacturing units.

To help this programme forward, the company proposes to engage a few first-class men to strengthen its Engineering Division. Applications are invited from men holding First or Second Class Honours Degrees in Mechanical or Chemical Engineering with some years of industrial experience following graduation. In addition to technical competence, the organisation requires men of energy and initiative with good personal qualities. The company would also be glad to hear from men who are graduating this year, who are free from National Service and who served a recognised apprenticeship.

Attractive starting salaries will be paid and those appointed should progress fairly rapidly to an initial salary ceiling of around £1300 per annum. Beyond this there is plenty of scope for progressive remuneration. The company works a five-day week in pleasant surroundings, and pension and profit-sharing schemes are in operation. Special mortgage facilities can be granted towards house purchase, and assistance is also available towards removal expenses. —BOX No. E6529, "The Engineer." A

A SENIOR DESIGNER, with experience in the centrifugal pump and/or compressor field, is required by Hamworthy Engineering, Limited, Poole, Dorset. This appointment holds excellent prospects to an engineer with the requisite design experience. It is envisaged that the successful applicant will hold either an Engineering Degree or H.N.C., combined with apprenticeship. An attractive starting salary will be offered, and assistance with housing will be provided, if necessary. A contributory superannuation scheme is in operation.—Please write, in complete confidence, to the Personnel Officer, giving fullest possible details of qualifications and experience. E6655 A

AN IMPORTANT COMPANY engaged in the design and development of major guided weapon projects require an EXECUTIVE ASSISTANT for administrative duties. The successful candidate must be trained in electronic or electrical engineering, and the qualifications should include a University Degree or similar standard of attainment in the Services, and, in addition, workshop experience would be an advantage.

Applicants should be proficient in administration and be familiar with committee and associated office procedure. Their age should not be less than 30, although consideration would be given to an applicant below this limit in exceptional circumstances.

This is a responsible position and will carry an attractive salary and excellent prospects.

Pleasant working conditions and amenities are provided and a generous pension scheme is in operation.

Replies will be treated in the strictest confidence, and should be addressed, quoting reference Comp/4, to:

T.A.O., BOX No. E885, "The Engineer." A

APPLICATIONS ARE INVITED for the following appointments at the Claydon, Suffolk, Works of
THE BRITISH STEEL PILING CO., LTD.

STRUCTURAL DESIGNER-DRAUGHTSMAN

(minimum qualifications H.N.C. or equivalent). Candidates should be capable of accepting responsibility for complete projects.

MECHANICAL DESIGNER-DRAUGHTSMAN

(minimum qualifications H.N.C. or equivalent, but consideration also given to candidates who have not yet completed their studies).

Experience should preferably (but not essentially, include equipment such as cranes, hoisting machinery (steam, diesel, electric), mechanical handling equipment, contractors' plant.

THESE ARE PROGRESSIVE, PERMANENT POSITIONS IN AN EXPANDING ORGANISATION. The Company operates a contributory pension scheme and good canteen facilities exist. Present holiday arrangements respected. Salary in accordance with age, qualifications and experience. The works are situated 15 minutes bus ride from the centre of Ipswich.—Applications to Works Manager at the above address. E6712 A

ARMSTRONG SIDDELEY MOTORS invite applications from Junior and Senior MECHANICAL DESIGNERS and TECHNICAL ASSISTANTS to join their project design team for work on aircraft gas turbines and a variety of other fascinating problems associated with supersonic flight. This is an exceptional opportunity for the above average designer, accustomed to higher-class work and with a flair for inventiveness, originality and responsibility to gain experience and knowledge in pleasant surroundings. Very attractive salaries will be paid for experience.—Applications, quoting ref. SR/DA, to Technical Personnel Manager, Armstrong Siddeley Motors, Ltd., Coventry. E6309 A

SITUATIONS VACANT

AERO ENGINE CONTROL SYSTEM.—ENGINEERS are required for a newly formed department dealing with various theoretical aspects of aero engine control problems. Experience of servo mechanism analysis and gas turbine engine performance investigation is desirable.—Applications, quoting END, to Technical Personnel Manager, Armstrong Siddeley Motors, Coventry. E873 A

APPLICATIONS ARE INVITED FROM ASSOCIATE AND GRADUATE MEMBERS OF AN ENGINEERING INSTITUTION, WHO ARE INTERESTED IN THE POSSIBILITY OF JOINING A WELL-KNOWN MANUFACTURING FIRM IN THE MIDLANDS FOR

TRAINING IN MANAGEMENT.

Candidates should be about 30 years of age and have had industrial experience.
Personal qualifications required are adaptability, an analytical mind and leadership.
A generous salary and, if necessary, assistance with housing is offered.

Replies should state age, qualifications, experience and present salary.—BOX No. E6524, "The Engineer." A

APPLICATIONS ARE INVITED from ENGINEERS for work on research and development of AUTOMATION TECHNIQUES AND PRODUCTION PROCESSES for the engineering industry. Previous experience not essential. Candidates should have an Engineering or Science Degree, Higher National Certificate or equivalent qualification. Send full details, including age, qualifications, experience and present salary in confidence.—BOX No. E6458, "The Engineer." A

ASSISTANT TO CHIEF ENGINEER.—London rubber manufacturers require a young man with sound training in engineering, including some drawing office experience and sound knowledge of steam raising plant. Duties will include control of staff, maintenance and installation of new plant.—Please write, stating details of any qualifications, past experience, previous position held and salary required, to BOX W.188, c/o Streets, 110, Old Broad Street, E.C.2. E6683 A

ATOMIC ENERGY

SENIOR MECHANICAL ENGINEER required by consulting engineers at Newcastle upon Tyne.

The work involves superintending overall and detail design of all mechanical plant associated with a nuclear power station. The preparation of specifications and adjudication of tenders will be part of his duties, also all correspondence with clients and contractors during the design and construction period.

The post is pensionable—five-day week—interesting work in congenial atmosphere.

Apply in writing, quoting reference S.E., to :

MERZ AND McLELLAN,
CARLIOL HOUSE,
NEWCASTLE UPON TYNE, 1.
E6703 A

BAHRAIN PETROLEUM COMPANY, LIMITED

Applications are invited from Graduate Engineers for the following vacancies in an expanding organisation :—

(a) CHEMICAL ENGINEERS, preferably experienced in design of pressure vessels, distillation columns, heat exchangers, pumping installations, &c., as encountered in petroleum refineries, or other heavy chemical industrial plants. Recent graduates accepted to train for advancement.

(b) MECHANICAL ENGINEERS, with similar experience to (a), recent graduates also being accepted for these posts.

Salaries according to qualifications and experience, with adequate living allowance, medical attention and air-conditioned quarters in addition. Pension scheme and kit allowance. Age limits 23 to 35. Apply, with fullest particulars, qualifications and experience.—BOX No. E804, "The Engineer." A

BECK AND POLLITZER are seeking three capable young MEN of good address interested in making careers in their expanding London industrial removal dept. They will receive intensive training in all aspects of heavy haulage work, especially machinery installations, removals and lifting, and will start to assume operational responsibility as soon as proficient. The work is arduous but varied and interesting. Pension scheme.—Write fully to E. Pollitzer Universal House, Southwark Bridge, S.E.1. E3852 A

BRITISH PETROLEUM COMPANY, LTD., has vacancies for MECHANICAL ENGINEERS at their Aden refinery. Applicants, aged 25–35, must possess either National Certificate or Diploma, preferably at Higher Level, or A.M.I.Mech.E. or First or Second Class M.O.T. Certificate or B.Sc. Degree. Full engineering apprenticeship essential, except in the case of those holding B.Sc. Degree, followed by three years' suitable experience in industry. Attractive salary plus generous allowance in local currency, free passages out and home, free medical attention, good leave arrangements, pension scheme, kit allowance and air-conditioned accommodation.—Write, giving full details of qualifications and experience, quoting F.506B, to BOX 1808, c/o 191, Gresham House, E.C.2. E6486 A

Classified Advts. continued on page 6

SITUATIONS VACANT

BRITISH CELLOPHANE, LIMITED, Bridgwater, Somerset, seeks SENIOR AND JUNIOR DRAUGHTSMEN, for both PERMANENT and TEMPORARY appointments, for work on machine design and chemical plant layout. Applicants should possess at least O.N.C. and have had three years' shop experience. Five-day week, pensions fund scheme for permanent appointments. Ref. No. E56 Er.

The TEMPORARY appointments are for a period of approximately two years' duration, subject to three months' notice and include generous subsistence allowances, and periodic home return rail fares.

ASSISTANT ENGINEER, age 23/30 (permanent). Applicants should have an Honours Degree in Mechanical Engineering and have had some practical works experience. The duties will be on development, improvement and maintenance of chemical and other plant. Ref. No. E57 Er.

SECTION LEADER DRAUGHTSMAN (permanent), in connection with the design of factory services. Applicants should possess H.N.C., have had at least three years' shop experience, and be familiar with all types of pipework installations. Ref. No. E58 Er.

ASSISTANT ENGINEER, age 25/30 (permanent). Applicants should have a university Degree and have works experience, or be an A.M.I.Mech.E. The duties will be on development, improvement and maintenance of plastic films extrusion plant and ancillary equipment. Ref. No. R48 Er.

Write to the Personnel Officer, stating full particulars and salary required, and qoute ref. Nos. as indicated. E6394 A

BUYER required to take control of section of buying department under chief buyer. Sound engineering background required with adequate experience of purchasing for mechanical engineering. Knowledge of electrical engineering also desirable. Factory and offices situated in Hampshire market town. Please write, giving details of age, experience and qualifications, present salary, salary required, married/single.—BOX No. E6714, "The Engineer." A

CHEMICAL ENGINEERS FOR REFINERY PROCESS ENGINEERING POSITIONS

The Bahrain Petroleum Company, Limited, has openings in their Research and Development Department for Graduate Chemical Engineers interested in refinery technical service work concerned with evaluation of process performance, process and product quality control and technical planning of forward operations.

Applicants should be under 35 years of age and preference is for those with previous similar experience in oil refineries or allied plants, though newly graduated men accepted for training.

Salaries are in accordance with qualifications and experience, with adequate living allowance, air-conditioned accommodation. Medical attention provided with kit allowance, pension scheme, paid local and home leaves, and out and home passages. Apply in writing with full particulars to Caltex Services Limited, Thames House South, Millbank, London, S.W.1. E860 A

CHIEF DESIGN AND DEVELOPMENT ENGINEER required by well-established firm, Eastern Counties, for equipment allied food industry. Applicants must state age and give full details past experience, also salary required.—BOX No. E3806, "The Engineer." A

CHIEF ENGINEER.—Leading British company, with overseas connections, requires a Chief Engineer to supervise the civil, mechanical and electrical constructional work on site of a major engineering project. Applications will be considered only from senior engineers with wide experience of such work. The post is a home appointment and depending upon experience carries a salary in the range £2500–£3500. Amenities include a house purchase scheme and pension fund. Applications will be treated as strictly private and confidential, and should state age, qualifications, experience and present salary.—BOX No. E6480, "The Engineer." A

CHIEF ENGINEER.—Sketchley, Limited, Hosiery Dyers and Dry Cleaners, invite applications for the post of CHIEF ENGINEER responsible to the board for technical advice and for maintenance of plant at the company's four works. Preference will be given to applicants aged between 35 and 45, with experience of water-tube boilers and back-pressure turbines, and with general maintenance experience of industrial plant. The position is permanent and pensionable. Housing assistance is available if required. Remuneration will be according to experience, but will not be less than £2000 per annum.—Applications should be addressed to the Secretary, Sketchley Dye Works, Hinckley, Leicestershire, and marked "Confidential." E6671 A

CIVIL ENGINEERING MANAGER.—Leading British company, with international organisation, requires services of qualified Civil Engineer to take control of major projects. The company has headquarters in London and will only consider applications from fully qualified Civil Engineers holding University Degrees in Civil Engineering or Associate Membership of the Institution of Civil Engineers. The successful applicant will be required to take complete control of large civil engineering projects, each representing several million pounds in value. Extensive experience in the organisation, design and costing of large civil engineering works is essential. The appointment will be based on London headquarters and carry a salary within a scale of £3000/£4000, dependent on qualifications and experience. Pension scheme and assistance for house purchase are available. Applications, stating age, experience, qualifications and present salary, which will be treated in strictest confidence, should be sent.—BOX No. E6479, "The Engineer." A

CHIEF ENGINEER required by textile manufacturing company—a vertical organisation with spinning, weaving, finishing and power plant on one site. Will be responsible for control of steam, generation and utilisation plant, mechanical, electrical work, and for preventive maintenance. Applicants must be Corporate Members of one of the senior Engineering Institutions. Good superannuation scheme. House available.—Applications to Personnel Director, Ferguson Brothers, Limited, Holme Head Works, Carlisle. E3834 A

CHIEF ESTIMATING ENGINEER required by fabricators of wide variety of chemical plant and equipment in stainless steel, mild steel and aluminium. Attractive salary to man of wide experience.—BOX No. E6718, "The Engineer." A

CIVIL ENGINEERS required by consultants with offices in Glasgow, for work on large hydro-electric projects and steam power stations. Vacancies exist for Assistant Engineers to be engaged on design and also on site supervision. Applicants must have passed or be exempt from Parts I and II of the Associate Membership examination of the Institution of Civil Engineers. Apply by letter, with particulars of age, qualifications and experience.—BOX No. E864, "The Engineer." A

CLEVELAND BRIDGE AND ENGINEERING CO., LTD., have vacancies for qualified CIVIL ENGINEERS, STRUCTURAL ENGINEERS and DESIGNER-DRAUGHTSMEN mainly on bridgework in the U.K. Salaries commensurate with experience. Pension scheme available. Posts in Darlington, Doncaster, Preston.—Apply in writing to the Managing Director, Post Box No. 27, Darlington, Co. Durham. E6569 A

CONTRACTS ERECTION MANAGER, fully conversant with all aspects of erection of riveted and welded gasholders, tanks and structural work. Attractive salary, pension scheme, and car allowance. —State age and full details of past experience, to The Managing Director, Robert Dempster and Sons, Ltd., Elland, Yorks. E3856 A

CONTRACT & TENDERING ENGINEERS

with experience of
STEAM POWER STATIONS

are invited to apply to the Chief Personnel Officer, BRUSH Electrical Engineering Co., Ltd., Loughborough, Leics. Several vacancies exist for this work in the expanding General Engineering Division, and early appointments will be made. There is ample scope for the exercise of initiative for those capable of working with the minimum of direct supervision, and preference will be given to applicants with recognised qualifications.

Applications are also invited from those with a comprehensive background of steam power stations, preferable with experience abroad, who lack the necessary commercial experience, but are willing to learn. Suitable training can be given.

There are progressive posts with excellent prospects, including a staff bonus and non-contributory pension scheme, and offer the opportunity of working in congenial conditions in a pleasant country town, but within easy reach of the East Midlands cities. E6533 A

CONVEYOR DESIGNER AND PRACTICAL ENGINEER

of first-rate abilities and of wide and varied experience, required for surface work by South Midlands company, man capable of organising and taking complete charge of surface conveyor department, with vision to expand. Car and telephone provided, assistance given with purchase of house. Reply, stating age, experience and salary required.—BOX No. E6656, "The Engineer." A

COURTAULDS LIMITED requires a DESIGN ENGINEER at its engineering headquarters in Coventry for development work on man-made fibre-making plant and machinery. A good Engineering Degree is essential, and several years' industrial experience in the design and development of chemical, textile or allied process plant and machinery is desirable. Age 27 to 40. Applicants should have an aptitude for solving design problems and calculations in this type of engineering.—Candidates should write, giving full personal particulars and details of experience, to the Director of Personnel, Courtaulds Limited, 16, St. Martin's-le-Grand, London, E.C.1, quoting reference number B.36. E6335 A

DESIGN DRAUGHTSMEN.—The British Drug Houses, Ltd., invite applications from suitably qualified men for interesting work in their engineers' drawing-office, on special machines and plant layouts for the light chemical industry. Higher National Certificate in Mechanical Engineering and previous experience in this industry desirable, but not essential. Men of mature age with suitable training and experience would be considered. Five-day week, pension and profit-sharing schemes.—Write, stating age, experience and salary required, to Staff Manager (Ref. B. 8945), Graham Street, City Road, N.1. E6295 A

DESIGNER-DRAUGHTSMEN AND DRAUGHTSMEN required in the Structural Steelwork Department of a large firm of Consulting Engineers. Experience in all-welded design and detailing an advantage but not essential. The department handles an extremely wide range of steel structures.—Please reply, giving details of previous experience, to BOX No. 455, Glovers Advertising, Ltd., 351, Oxford Street, W.1. E888 A

DEVELOPMENT ENGINEERS AND TECHNICIANS required in Research Department of a well-known firm of precision engineers, particularly for work in connection with servo systems, small precision motors and gyroscopic instruments.—Apply, stating age, experience and salary required, to S. G. Brown, Ltd., Shakespeare Street, Watford, Herts. E746 A

DESIGN DRAUGHTSMEN, experienced in bulk handling of materials, required for head office of London company. Salary £850/£950, plus according to experience. Pension scheme.—BOX No. 713, Smiths', 100, Fleet Street, London, E.C.4. E6708 A

WILLIAM DOXFORD & SONS, LTD., ENGINEERING DEPT., PALLION, SUNDERLAND.

DRAUGHTSMEN

Vacancies exist for Senior Detail and Machinery Arrangement Draughtsmen for varied and interesting work on large marine oil engines. Good prospects. Pension scheme. Salary according to age and experience. Interviews can be arranged for Saturday mornings. Applications should be addressed to Chief Draughtsman. E3861 A

DRAUGHTSMAN required for engine design schemes on small high-speed diesels. Must have initiative and experience. Good salary, pleasant working conditions. Pension scheme.—Apply, Chief Personnel Officer, Petters, Limited, Causeway Works, Staines. E865 A

DRAUGHTSMEN AND DEVELOPMENT ENGINEERS

MECHANICAL AND ELECTRICAL

Well-established manufacturer of Industrial Vehicles in country district, with easy access to London, invites applications. Excellent salaries, housing assistance and other allowances in approved cases. O.N.C. or H.N.C. preferred.

Own staff advised of this advertisement.

Write.—BOX No. E6685, "The Engineer." A

DRAUGHTSMEN required by Northern Aluminium Company, Ltd., Banbury, Oxon. Qualifications, H.N.C. preferred, but O.N.C. considered; workshop training an advantage. Permanent positions to suitable applicants. Pension and life assurance scheme in operation, also welfare and sports facilities.—Write, Personnel Manager, stating age, experience and salary required. E6676 A

DRAUGHTSMEN required in various drawing-offices at Fort Dunlop. There are exceptionally good opportunities for draughtsmen interested in plant layout (including services), special-purpose machine design, and tyre design. Promotion comes swiftly to keen and efficient men. There is a good pension scheme.—Please write, giving age, experience and salary required, to Personnel Manager (M.18), Dunlop Rubber Co., Ltd., Fort Dunlop, Erdington, Birmingham, 24. E6437 A

DRAUGHTSMEN (Senior and Junior) required for work in connection with the following branches of coke oven and gasworks plants :—
(a) Mechanical and By-Product Plant.
(b) Pipework.
(c) Steelwork for Buildings and Conveyors.

Applicants should be competent men able to work with the minimum of supervision. Technical qualifications to O.N.C. or beyond. Good remuneration and prospects for capable men. Pension scheme. Five-day week; canteen facilities.—State age and experience to the Personnel Officer (D.O.), Woodall-Duckham Construction Company, Ltd., Woodall-Duckham House, 63–77 Brompton Road, London, S.W.3. E672 A

DRAUGHTSMEN, Senior and Junior, preferably with railway or automotive experience, required for diesel traction drawing-office situated in London area, N.W.10.—Apply in writing, giving age, details of experience and salary required, to General Manager, British United Traction, Ltd., 14, Hanover Square, London, W.1. E6492 A

DRAUGHTSMEN.—Edwin Danks and Co. (Oldbury), Ltd., Oldbury, Nr. Birmingham, manufacturers of all types of pressure vessels, have vacancies for SENIOR DRAUGHTSMEN and DETAILING DRAUGHTSMEN. The work, which is interesting, covers a wide field in the design of all classes of welded vessels for industrial plants, chemical plants and oil refining plants. The positions are permanent, and the company has a contributory pension scheme and other facilities, and conditions associated with first-class employers. Applicants should be competent men, able to work with a minimum amount of supervision. Please write, giving age, details of training and experience. Salary according to qualifications and experience; interesting work and canteen facilities provided.—Apply, Chief Engineer, Edwin Danks and Co. (Oldbury), Ltd., Oldbury, Nr. Birmingham. E6568 A

ENGINEER to head Rail Traction Division of Sales Department of well-known firm manufacturing diesel engines. Applications should be from candidates with first-hand knowledge of railway requirements, preferably from employment thereon. B.Sc. or Higher National Certificate desirable but not essential if experience sufficient of diesel engines, diesel rail traction applications, and sales. Full details should be addressed to the Personnel Manager. —BOX No. E3849, "The Engineer." A

ENGINEERS aged 25/32, for development and experimental work, are offered opportunities for advancement by a rapidly expanding firm in the Leicester area. H.N.C. minimum qualification, works experience, with knowledge of press tool and plastic moulding an advantage. Particulars, together with salary required.—BOX No. E6681, "The Engineer." A

ESTABLISHED OIL BURNER manufacturer require LONDON SALES REPRESENTATIVE with good technical qualifications and knowledge of power plant, to handle and develop business in industrial field. Excellent opportunity and prospects. Commencing salary about £1000 p.a., depending on candidate. Reply in confidence.—BOX No. E3[illegible], "The Engineer."

EXPERIENCED DESIGN DRAUGHTSMAN required for scheme work on fuel injection equipment, centrifugal hydraulic governors and other hydraulic equipment. Good salary, attractive pension scheme, pleasant working conditions.—Please apply, Chief Personnel Officer, Bryce Berger, Limited, Ironside Works, Staines, Middx. E870

EXPERIENCED PLANNING ENGINEER required for production methods on medium [illegible] engine components and fuel injection equipment. Pleasant working conditions, generous [illegible] Attractive pension scheme and [illegible] welfare facilities.—Apply, Chief Personnel Officer, Petters, Ltd., Causeway Works, Staines, Middx. E872

FERODO, LIMITED, CHAPEL-EN-LE-FRITH, Via Stockport, have vacancies for the following :—

1. GENERAL ENGINEERING DRAUGHTSMEN, age 25 to 40, having experience in Machine Design and Works Layouts. A knowledge of Works Building Design desirable but not essential. Technical education at least to O.N.C. Ref. 2444/1.
2. JIG and TOOL DRAUGHTSMEN, age 21 to 40. A knowledge of General Engineering and Machine Design advantageous but not essential. Technical education at least to O.N.C. Ref. 2444/2.

Suitable applicants are offered excellent working conditions and canteen facilities. There is a contributory superannuation scheme.

You are invited to submit full details of experience, age, qualifications, and salary required to the Personnel Manager, quoting the appropriate reference number. E6636 A

FERODO, LIMITED, CHAPEL-EN-LE-FRITH, manufacturers of friction materials, invite applications for the following positions on the Test House Staff :—

1. DRAUGHTSMEN-DESIGNER, to design new test machine and new devices for the measurement of friction thereon. Candidates must have drawing-office experience in design and stress work and should have at least an Ordinary National Certificate and preferably a Higher National Certificate in Mechanical Engineering or equivalent. Ref. No. 5033/1.
2. A TECHNICAL ASSISTANT to carry out investigations on the performance of test machines leading to the improvement of machines, testing procedures and methods of recording; also to organise special tests on proprietary brakes, clutches, overdriven, &c. Candidates should have at least an Ordinary National Certificate in Mechanical Engineering. Ref. No. 5033/2.
3. A TECHNICAL ASSISTANT to divide his energies, according to varying priority, between the two types of work specified above, i.e., part design and part experimental work. Candidates should have at least an Ordinary National Certificate in Mechanical Engineering. Ref. No. 5033/3.

These are staff positions at attractive salaries and carry a pension.—Applications, quoting the appropriate reference number and giving full personal details, including present salary, should be submitted in confidence to the Personnel Manager. E6635 A

FISONS LIMITED invite applications from qualified DRAUGHTSMEN for the following two positions :—

a. Chemical Plant Senior or Designer Draughtsman for layout and design work in connection with heavy and fine chemical plant.
b. Mechanical Senior or Designer Draughtsman for layout and design work on mechanical handling plant in Fertilizer Works.

Applicants should have had a good general education with at least five years' experience in similar work, preferably with some practical experience. Technical qualifications should include the Higher National Certificate or its equivalent. Excellent working conditions, five-day week, contributory pension and widows' pension schemes, &c.

Applications, stating age, qualifications, experience, &c., to Personnel Officer (CY), Fisons, Limited, Harvest House, Felixstowe, Suffolk. E5903 A

THOMAS GLOVER AND COMPANY invite applications for the position of ASSISTANT WORKS MANAGER at their Edmonton factory. Applicants should possess proved administrative ability and have had considerable experience of production methods in the light engineering industry. Age 30 to 45 years. Commencing salary will be not less than £1250 per annum, with good prospects. A superannuation scheme is in force.—Applications, stating age, qualifications, experience and present salary, should be addressed to the Managing Director, T. Glover and Co., 48, Grosvenor Gardens, London, S.W.1. E6606 A

GRADUATE ENGINEERS (MECHANICAL) required immediately for a progressive Chemical Industry located in the North of England. These vacancies are for design work in the Chief Engineer's Department, and are of special interest to young engineers with a flair for design and development work, who have served a Graduate apprenticeship. The age range is 26/33, and the salary within the range of £1000/£1500, depending upon age, qualifications and experience. There is a scheme for assisting married men with house purchase and removal expenses. Annual bonus and pension schemes are attractive. Applications, which will be treated with the strictest confidence.—BOX No. E6608, "The Engineer." A

SITUATIONS VACANT

GRADUATE ENGINEERS, age 25/30, required to train for Executive Positions in Production and Works Management in medium/heavy engineering industry, producing earth-moving equipment, in progressive and up-to-date factory.—Applications, in writing in first instance, giving all relevant particulars and approximate salary required, to Personnel Manager, Ruston-Bucyrus, Ltd., Lincoln. E6610 A

HOLLERITH
DESIGN AND DEVELOPMENT ENGINEERS

The continuing expansion of the Company offers excellent opportunities for senior engineers who are interested in the development and design of high-speed electro-mechanical punched card accounting machines.

Qualifications looked for include a recognised Degree, Higher National Certificate, or equivalent standard and previous shop and design experience, preferably in the electro-mechanical field.

Facilities include pension fund, sick pay, and further education arrangements. Applications or inquiries should be addressed to the Personnel Superintendent (ref. E/628):
THE BRITISH TABULATING MACHINE CO., LTD.,
Icknield Way, Letchworth, Herts.
E6567 A

HYDRAULICS. — First-class Technical Sales Manager required for the development of home and export sales. Experienced in all types of hydraulic and pumping machinery essential. Apply in strict confidence, giving full details of training, past and present employment, age and references.—BOX No. E3863, "The Engineer." A

HYDRAULICS.—Glasgow firm, specialising in centrifugal pumps of all sizes and types, has vacancies for several men interested in hydraulic design and development. Candidates should have training to University Degree or Technical College Diploma standard and have served an engineering apprenticeship. A.M.I.Mech.E. is an advantage. Good salary, depending on qualifications and experience. Pension scheme available. As experience is gained, these openings offer excellent opportunities for advancement for a man with initiative, able to translate his ideas into practical form.—Applications, stating training, experience and salary expected, should be addressed in writing to 2061 Wm. Porteous and Co., Glasgow. E6691 A

INSPECTING ENGINEER for contractors' plant, vehicles and equipment. Background should preferably include apprenticeship as fitter, followed by several years' experience of British and American construction equipment. Experience of preventive maintenance and ability to make detailed reports essential. Good prospects of advancement. State age and experience.—BOX No. E6565, "The Engineer." A

JUNIOR DRAUGHTSMEN, having completed National Service, required for work on large chemical plant installations, A.E.S.D. minimum rates or above. Five-day week and superannuation scheme. —Apply by letter, giving details of technical education, to the Chief Draughtsman, Laporte Chemicals Limited, Clifton House, Euston Road, London, N.W.1. E880 A

JUNIOR DRAUGHTSMEN required, O.N.C. standard, experience in general engineering and/or sheet metal fabrications for work on specialised equipment for the dairy, brewery and chemical industries. Salary commensurate with experience.—BOX No. E3846, "The Engineer." A

LARGE CIVIL ENGINEERING COMPANY with headquarters in the Liverpool area, carrying out railway electrification schemes, require to expand their technical and drawing-office staffs immediately. Applications are accordingly invited from DRAUGHTSMEN (Mechanical or Structural), TECHNICAL ASSISTANTS (Civil or Mechanical) qualified to a minimum of O.N.C. standard, for the design, estimating and engineering sections. Excellent rates of remuneration and conditions of service, including a five-day week.—BOX No. E6498, "The Engineer." A

LEADING MANUFACTURERS of container closures in the Midlands have a number of vacancies for ambitious DESIGN DRAUGHTSMEN, preferably with some experience in this or a similar sphere. Interesting work with excellent salary and every opportunity for promotion to senior position in a rapidly growing organisation.—Write in confidence, with details of experience, positions held, salary required, to P.A. Metal Closures, Limited, Bromford Lane, West Bromwich. E832 A

MECHANICAL DESIGNER/DRAUGHTSMEN required by large firm of consulting engineers for work in the West Kent area and also for their London office (Victoria). Candidates should hold O.N.C. or equivalent.—Please write, giving details of previous experience, to BOX No. 433, Glover's Advertising, Limited, 351, Oxford Street, London, W.1. E883 A

MECHANICAL ENGINEER with Honours Degree required in chief engineer's department of large textile company in West Riding. Initially the work will involve investigation into power and steam and other services and processes and will later broaden to include the design, installation, operation, maintenance and repair of power and other plant installations at the various branch factories of the company. Previous experience of steam and mechanical and electrical power generation and distribution desirable. The company is seeking a first-class man, age 25-32, and a commencing salary of up to £1250 per annum will be paid according to qualifications and experience. The prospects are good and the company operates an excellent superannuation scheme. Arrangements for applicants previously considered will stand. Applications, giving full details of career to date, age and present salary, in strict confidence.—BOX No. E3803, "The Engineer." A

MANAGEMENT SELECTION, LIMITED

invite application for the position of

INSTRUMENT ENGINEER

with a chemical manufacturing company in East London having over 1000 employees. The person appointed will take charge of the design, installation and maintenance of all plant instrumentation. For suitably qualified engineers salary is progressive up to a maximum of about £1700; probable age 28-45. Knowledge of chemical manufacturing processes desirable.

No information will be passed to our clients without candidate's permission at interview.—Please write, in confidence, to H. E. Roff, Management Selection, Ltd. (G.129), 8, Clarges Street, London, W.1. E6715 A

MANAGEMENT TRAINEE required in a small South London factory on batch production making electro-mechanical industrial equipment. Candidates must have a Degree or H.N.C. in Mechanical or Mechanical/Electrical Engineering. One to three years' factory experience and ambition towards the managerial and production side rather than technical/design work. Age should not exceed 27. Interviews to take place in August.—Write, BOX E 787, L.P.E., 55, St. Martin's Lane, London, W.C.2. E6663 A

MECHANICAL/ELECTRICAL ENGINEER required for old-established mining company in Malaya. Thorough technical and practical training with wide experience of mining machinery essential. Electrical experience desirable, but not essential. Good salary offered in accordance with qualifications; 3/3½-year contract with free house, light, water; medical, provident fund passages and six months' fully paid leave on completion with renewal of contract if mutually satisfactory.—Replies to W. R. Loxley and Co. (London), Ltd., Plantation House, Fenchurch Street, London, E.C.3. E6643 A

METALLURGIST.—Wanted for South African steelworks, Assistant Works Metallurgist with knowledge chemical analysis, steelmaking, manufacture and heat-treatment alloy and tool steels. Salary £900 per annum and upwards, according to experience. Good prospects. Fare paid to South Africa including family. Graduate preferred.—Apply in writing to London Representative, Union Steel Corporation (of South Africa), Ltd., 723, The Adelphi, London, W.C.2, giving full details of experience and qualifications. E6521 A

METHODS ENGINEERS.—Well-known large engineering company, engaged in batch production of precision equipment and machines, requires several Methods Engineers at factories in the Birmingham area and in South Wales. Applications are invited from Production Engineers with experience of modern machine shop practice, and who are interested in production cost reduction. Posts will be permanent and pensionable. Good working conditions. Applications should give details of training and experience, and should state salary required.—BOX No. E6679, "The Engineer." A

MONSANTO CHEMICALS, LIMITED, London, have vacancies for DRAUGHTSMEN having experience of instrumentation work in the chemical manufacturing or oil refining industries. Applicants should preferably possess the H.N.C. in Mechanical or Electrical Engineering and be able to work on own initiative and in co-operation with design engineers. The posts, which offer scope for advancement, are permanent and pensionable, and good salaries according to experience are offered. Five-day week and staff restaurant are in operation. —Applications, in writing, giving full details of age, training and experience, should be sent to the Chief Personnel Officer, Monsanto Chemicals, Limited, Monsanto House, 10–18, Victoria Street, London, S.W.1. E6587 A

PLANNING ENGINEER with considerable experience required for planning and improving production methods of medium/light I.C. engine components. Salary commensurate with qualifications demanded. Pension scheme.—Apply to Chief Personnel Officer, Petters Limited, Causeway Works, Staines. E821 A

PLANT ENGINEER, age 35–45, required by company embarking on a new project in the Carlisle area. Applicant must possess suitable technical qualifications backed with practical experience. He must have an extensive knowledge of plant layout, electrical, mechanical and boiler maintenance, and must have controlled labour. A good salary will be paid according to experience and the post is suitable for an ex-Naval or shipyard engineer. Interesting work with an expanding company possessing a first-class reputation for the welfare of its employees.—Applications in confidence should be addressed to BOX No. E6709, "The Engineer." A

PROJECT ENGINEER required, with minimum qualifications of H.N.C. and with experience of design and specification of diesel engines. Duties will be to maintain technical liaison with customers in order to draw up and complete specifications of equipment required to meet their application. Good salary, pleasant working conditions.—Apply, Chief Personnel Officer, Bryce Berger, Limited, Ironbark Works, Staines, Middx. E877 A

PIPING DRAUGHTSMAN required for permanent position in the London offices of a large firm of consulting engineers. Salary will be high and commensurate with experience. Pension scheme, excellent conditions. Apply with full particulars of experience.—BOX No. E6454, "The Engineer." A

REQUIRED by large progressive and old-established manufacturing company in South-West England a Chief Draughtsman for the engineering drawing-office employing 20/24 draughtsmen. The work entails plant layouts, extensions, special equipment and machine design, general routine work involved with a large factory using comprehensive equipment and services. Applicants should already have had experience in this capacity and should give full particulars. A salary commensurate with the responsibilities and experience involved will be paid, and assistance will be provided regarding accommodation during the early months after taking up the appointment.—BOX No. E6637, "The Engineer." A

RESEARCH ASSISTANT.—Male assistant, 25-35 years, is required for research into problems associated with fuel injection for diesel engines. Research experience plus knowledge of fuel injection is desirable, but some training will be given. Good general education and H.N.C. (Mech.) an advantage. Applicants should be capable of section leading after reasonable period.—Apply in writing, giving full details, Personnel Officer, Simms Motor Units, Ltd., Oak Lane, E. Finchley, N.2. E6412 A

RUSTON AND HORNSBY, LTD., require, for London, ESTIMATING ENGINEER, age 25–30, who, after period of training, will be capable of preparation of tenders for sale of oil engines and associated equipment. The position, which normally holds prospects of advancement in the Sales Organisation, requires ability, based on good education and sound knowledge of engineering principles.—Please write in first instance to London Manager, Ruston and Hornsby, Ltd., 95, Aldwych, W.C.2. E6723 A

SENIOR AND JUNIOR DESIGNERS for reinforced concrete and/or steelwork required for London office. Considerable scope for advancement. Junior assisted in study courses involving day attendance. Consideration given to holiday arrangements.—BOX No. E3810, "The Engineer." A

SENIOR CIVIL ENGINEER, preferably with some experience welded steel structures, required for Gibraltar. Married accommodation available.—Write, Personnel Manager, John Howard and Co., Ltd., 13, Buckingham Gate, London, S.W.1. E6682 A

SENIOR DESIGN DRAUGHTSMAN required for interesting structural and mechanical work. Previous experience on mechanical handling equipment desirable, but not essential. Good rates of pay, luncheon vouchers. Pension scheme in operation. Present holiday arrangements considered.—Write or telephone Ropeways, Ltd., 62, London Wall, London, E.C.2 (NAT 0124/5). E886 A

SENIOR DESIGN DRAUGHTSMEN and **ESTIMATING DRAUGHTSMEN** required, preferably with experience in package handling equipment, conveying and elevating machinery, also general mechanical handling installations. The positions are permanent and offer excellent propsects to suitable and successful applicants. Salary range from A.E.S.D. minimum to £1000 p.a. for experienced men. Five-day day week, pension and B.U.P.A schemes in operation. Present holiday arrangements will be honoured.—Apply in confidence, stating age experience, to British Wedge Wire Co., Ltd., Elmswood, 52, Bounds Green Road, Bounds Green London, N.11. All members of our staff have been notified of the positions vacant. E3802 A

SENIOR DESIGN DRAUGHTSMEN required by large engineering concern engaged in the manufacture of agricultural and earth-working machinery. Applicants should have some experience in gearing and transmission, oil hydraulic systems, production methods, materials and treatments, and drop-forging and foundry techniques. H.N.C. or equivalent essential. Good salary paid to successful applicants. Further amenities include superannuation scheme, modern canteen facilities, active sports and social organisations with extensive playing fields. Modern works and offices, situated in pleasant rural area 30 miles from London. Housing assistance given to successful applicants from the London area. Interviews may be arranged at any time, including Saturday morning. Write, in confidence, giving details of age, experience, positions held and salary required.—BOX No. E6226, "The Engineer." A

SENIOR DRAUGHTSMAN required for interesting work on plant layout; opportunity of travelling to customers' works. Previous experience of this type of work an advantage, but not essential. Good wages and pensions scheme.—State age and full experience and salary expected, to Employment Office, Alfred Herbert, Ltd., Coventry. E6570 A

SENIOR DRAUGHTSMAN required, with experience of earth moving equipment, for interesting work in a new section of large drawing-office in the East Midlands. H.N.C. standard. Knowledge of hydraulics and/or gear design an advantage. Excellent welfare and canteen facilities. House available. Apply, stating age, qualifications and experience.—BOX No. E6680, "The Engineer." A

SENIOR DRAUGHTSMAN wanted for makers of machine tools and sheet metal machines. Non-contributory insurance and pension scheme. Age, experience, salary, &c.—F. J. Edwards, Ltd., 359, Euston Road, London, N.W.1. E6721 A

SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN required for interesting work on large chemical plant installations. Experience in this type of work is desirable, but not essential; applicants with general mechanical engineering experience will be favourably considered. The posts offer excellent opportunities with generous salaries commensurate with experience and ability. Offices situated in the N.W.1 London area. Five-day week and superannuation scheme.—Applications, which will be treated in confidence, should give previous experience and qualifications, and be addressed to the Chief Draughtsman, Laporte Chemicals, Limited, Clifton House, Euston Road, London, N.W.1. E881 A

Classified Advts. continued on page 8

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SITUATIONS VACANT

SENIOR JIG AND TOOL DRAUGHTSMEN required for tool design on : (a) Small I.C. engine components ; (b) Fuel injection and hydraulic control mechanisms on a production basis. Applicants should have experience in these or similar fields. Pleasant working conditions. Generous salary commensurate with qualifications demanded. Attractive pension scheme. Comprehensive welfare facilities.—Apply to Chief Personnel Officer, Bryce Berger Works, Staines, Middx. E876 A

SENIOR PRODUCTION ENGINEER

A large expanding light engineering company in South-West London requires a Senior Production Engineer. Applications are invited from men with appropriate qualifications and the successful candidate must have first-class knowledge and experience of administration, jig and tool design, process planning, work study, and must be acquainted with the most up-to-date production methods and techniques associated with electro-mechanical and electronic engineering. This is an excellent opportunity for a man of real ability to subsequently assume executive responsibility. Applications will be treated with strictest confidence and should be addressed.—BOX No. E3868, "The Engineer." A

SENIOR STRUCTURAL DESIGNER-DRAUGHTSMAN, aged 30 to 40, required for large British-managed engineering company in Calcutta, manufacturing major bridges, steelwork buildings, cranes of all types and capacities, sluice gates and other steelwork, both riveted and welded. Excellent prospects and terms.—Write, BOX JN/95, c/o 95, Bishopsgate, E.C.2. E6658 A

SHIFT CHARGE ENGINEER is required by the Mobil Oil Company, Limited, at the Coryton Refinery in Essex. The power station consists of three oil and gas-fired I.C.L. boilers operating at 650 p.s.i.g., 750 deg. F. m.c.r. each 180,000 lb. per hour and three 5000kW. Metro-Vickers double extraction condensing turbo-alternators extracting at 125 and 20 p.s.i.g., generating at 11·0kV, three-phase, 50 cycles. Allied to this there is water-softening equipment, consisting of hot lime pretreatment, hot zeolite finishing of 500,000 lb. per hour capacity with miscellaneous auxiliary equipment. Conditions of employment include a pension and life assurance scheme, sickness benefit plan and sports and social club. Housing may be made available to the successful applicant.—Applications, giving full details of qualifications and experience, should be addressed to the Employee Relations Superintendent, Mobil Oil Company, Limited, Coryton Refinery, Stanford-le-Hope, Essex. E6665 A

STRUCTURAL ENGINEER with wide experience of the design and detailing of all types of steel structures and with administrative experience, required to act as Deputy to the Chief Engineer by large firm of London Consultants. The firm is expanding and the vacancy offers excellent opportunities for the right type of man.—Write in confidence, giving details of previous experience and salary required, to BOX No. 356, Glovers Advertising, Ltd., 351, Oxford Street, London, W.1. E837 A

STRUCTURAL ENGINEER required by London firm of consultants, to take charge of their steel design office. Candidates must have a comprehensive knowledge of all types of structural steelwork, both designing and detailing, and should preferably have had some works experience. Applicants should be Corporate Members of one of the Senior Professional Institutions or hold similar Degrees. The post is a permanent one and there is a staff pension scheme.—Please reply in confidence to BOX No. 390, Glovers Advertising, Ltd., 351, Oxford Street, W.1. E850 A

THE FAIREY AVIATION COMPANY LIMITED

The Development Programme in our Helicopter field has resulted in the setting-up of extensive rotor tip jet test facilities at White Waltham, Berkshire. A special jig is also about to be erected at an establishment in Wiltshire.

A strong team of Research and Development Engineers is being formed, whose function is to design, develop and prove the various forms of tip jet propulsion systems for use on helicopters. At present the main effort is devoted to the pressure jet system for the Rotodyne.

For this team Two SENIOR DEVELOPMENT ENGINEERS are needed, preferably with experience in aero engine combustion. There will be an opportunity for a suitable candidate, after training, to be detached to the Wiltshire test rig, where there will be ample scope for initiative and sound engineering knowledge in running the test programme.

A high degree of formal academic knowledge is not essential, though possession of an H.N.C. or Engineering Degree would be a distinct asset.

Holiday arrangements for 1956 will be respected wherever possible.

Please send application, with details of career, &c., to the Personnel Manager, The Fairey Aviation Co., Ltd., Hayes, Middlesex. E6532 A

TECHNICAL DIRECTOR.—Leading British company with headquarters in London wishes to appoint a Technical Director. The position requires an experienced engineer, highly qualified, with wide experience in the design and construction of major engineering projects involving mechanical, civil and electrical engineering. The candidate appointed will have a seat on the board and will be responsible for the general administration and co-ordination of the design and engineering organisation involving the control of contracts running into several millions of pounds. Applications, which will be treated as strictly confidential, will only be considered from engineers having University Degrees and wide experience in the general design of the type of projects referred to in this advertisement. The salary level will be between £3000/£4000. The company operates a pension scheme and facilities for house purchase and removal expenses are available. Applications should state age, experience, qualifications and present salary.—BOX No. E6580, "The Engineer."

TECHNICAL ASSISTANT required for Engine Drawing-Office, to deal with design calculations, technical enquiries and engine instruction manuals. Salary commensurate with qualifications demanded. Pension scheme.—Apply to Chief Personnel Officer, Petters Limited, Causeway Works, Staines. E822 A

TEST AND LABORATORY ENGINEERS required for gyro and electro-mechanical instruments.—Apply, stating age, experience and salary required, to S. G. Brown, Ltd., Shakespeare Street, Watford, Herts. E756 A

THE SUPERHEATER CO., LTD., 53, Haymarket, London, S.W.1, has vacancies for TECHNICAL DESIGN ENGINEERS. Knowledge of thermodynamics, including combustion and heat transfer, desirable. Good working conditions, 5-day week. Pension scheme.—Write, giving full details of qualifications, experience and salary required. E6544 A

THE SUPERHEATER CO., LTD., 53, Haymarket, London, S.W.1, has vacancies for DRAUGHTSMEN. Experience of water-tube boilers preferred. Good working conditions. 5-day week. Pension scheme.—Write, giving full details of qualifications, experience and salary required. E6545 A

TIME STUDY ENGINEER required, with good workshop training. Modern, progressive factory, situated in pleasant surroundings, good salary, pension scheme.—Apply to the Chief Personnel Officer, Bryce Berger Limited, Ironbarks Works, Staines, Middlesex. E882 A

TO MEET A BIG NEW PROGRAMME of development, a large organisation with headquarters near London urgently requires more DRAUGHTSMEN. In particular, men are wanted who are experienced in work associated with chemical plant, e.g. pipework, vessels, heating and ventilating, drying, powder conveying and packing. Mechanical Draughtsmen are also wanted, since the programme includes development work in novel processes which are essentially mechanical in nature. In addition, there are vacancies for men with plant instrumentation knowledge. Attractive starting salaries will be paid, and pension and profit sharing schemes are in operation. Special mortgage facilities can be granted towards house purchase, and assistance is also available towards removal expenses. Apply in full.—BOX No. E6531, "The Engineer." A

WEST LONDON water treatment engineers require ASSISTANT for TECHNICAL SALES having Engineering or Chemical Degree. Pension scheme. Apply, with full details of qualifications and experience.—BOX No. E6678, "The Engineer." A

YOUNG PRACTICAL ENGINEER required, to initiate and manage section of general workshops devoted to continuous overhaul of item of contractors' plant. Applicant should have organising ability and sound training in mechanical fitting. Wage to commence £12/15 p.w., according to ability. Excellent prospects.—BOX No. E6700, "The Engineer." A

A.V.R.O.

WEAPONS RESEARCH DIVISION

A. V. ROE & CO., LTD.

INSTALLATION ENGINEER

required for design and development work connected with the ground and air launching of guided missiles. This is a senior staff position carrying a good salary and prospects of advancement in an expanding organisation. The Company has a Pension and Life Assurance Scheme, and the division is situated in pleasant surroundings with convenient access to Stockport and Manchester. Applicants should possess an Engineering Degree or H.N.C., and several years' design experience. Experience of Armament Installations would be an advantage. Applications to :

Chief Engineer,
Weapons Research Division,
A. V. ROE & CO., LIMITED,
Woodford, Cheshire.

E6660 A

HEAD WRIGHTSON & CO., LTD.

(McKee Iron & Steel Division)

have several vacancies for STRUCTURAL and MECHANICAL DESIGNER-DRAUGHTSMEN (Senior and Junior), for work on the design of materials handing, blast furnace and gas cleaning plants.

Applicants should preferably have experience of iron and steel works practice, but applications will be considered from Draughtsmen wishing to take up this class of work.

Excellent working conditions, five-day week, pension scheme.—Applications, stating age, qualifications and salary required, to Personnel Manager, Ref. M.K./12, Teesdale Iron Works, Thornaby-on-Tees. E6537 A

STRESSMEN

A number of STRESSMEN are required for interesting work in the Guided Weapons Division of SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT, LTD.

The minimum qualifications are H.N.C. in Mechanical, Aircraft or Structural Engineering, together with at least two years' experience in the stress office of an aircraft or guided weapons organisation.

Pleasant working conditions and amenities are provided and an attractive superannuation scheme is in operation. The work is of a permanent character in a new and expanding field, and the salaries are good.

All replies should be addressed to :

Technical Appointments Officer,
Sir W. G. Armstrong Whitworth Aircraft, Ltd.,
Baginton, Nr. Coventry.

quoting reference St/4/ARM/TAO.

E6283 A

THE HEAD WRIGHTSON MACHINE CO., LTD.

invite applications from first-class

DESIGN ENGINEERS
and
SENIOR DRAUGHTSMEN

who would be interested in progressive positions in a special development department which will shortly be opened to deal with a wide range of problems affecting several industries.

The company has a good pension scheme and allows generous holidays. Men having a sound technical training and a flair for design are recommended to submit applications, marked "Private (Development)" to : Managing Director, The Head Wrightson Machine Company, Ltd., Commercial Street, Middlesbrough. E6535 A

FRASER & CHALMERS ENGINEERING WORKS

ERITH, KENT

have vacancies for a number of

SENIOR DRAUGHTSMEN

with good experience in

STRUCTURAL OR HEAVY MECHANICAL WORK

Attractive salaries will be offered to suitable applicants and the positions available offer excellent prospects for advancement.

Present holiday arrangements will be honoured.

Apply to Personnel Manager, giving age and full details of training and experience.

E6591 A

GUIDED MISSILES

A SENIOR ENGINEER is required by an important company, engaged on major guided missile projects, to take charge of work associated with the flight trials of these weapons.

The main responsibilities of this post are to co-ordinate the work of a large group of technicians engaged on this task ; the work is of a very interesting and varied character, and covers overall system testing and the analysis and the behaviour of installations covering mechanical, hydraulic, electronic and electrical engineering.

A University Degree or its equivalent is required in one of the following branches of engineering :—

Servo-Control Systems, Electronic and Electrical Engineering, Radar, Radio and Telecommunications.

The salary scale will be commensurate with the high degree of responsibility associated with this senior post, and the successful applicant will be eligible for the company's attractive superannuation scheme.

All replies should be addressed to :
BOX No. E6284, "The Engineer," quoting reference L/2. A

WORKS MANAGER

FOR

AERO-ENGINE RESEARCH

AND

DEVELOPMENT PROGRAMME

A well-known Company invites applications from Engineers of suitable experience and proved administrative ability for the above appointment.

Applicants, who should be under 45, must be well qualified and capable of undertaking full responsibility for all manufacturing departments and workshops, undertaking an interesting and expanding experimental programme of national importance.

The position provides excellent prospects for advancement along with a good salary and pension scheme to a man possessing first-class leadership and initiative.

Applications, which will be treated in strict confidence, should give full details of experience, qualifications, &c., and be addressed to BOX AC.20149, Samson Clarks, 57–61, Mortimer Street, London, W.1. E6581 A

SITUATIONS VACANT

ADVANCED STEAM TURBINE DESIGN

The English Electric Company, Ltd., invite applications from Engineers wishing to take part in advanced design work on Steam Turbines.

A Special Course of Technical Education and Training will commence on October 1st, 1956. Applications are invited from young Graduates and Student Engineers and from men prematurely retired from the Technical Branches of the Services.—Please write to Dept. C.P.S., 336/7, Strand, W.C.2, quoting ref. 1107. E6668 A

SITUATIONS VACANT

B T-H

DRAUGHTSMEN

Senior and Junior, required for layout and DETAILING OF MECHANICAL GEARS of all sizes.

Applicants should have sound training and experience in good quality mechanical engineering, preferably including gears and fabrication of mechanical engineering structures.

Apply to :—
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GEAR FACTORY DRAWING-OFFICE,
BRITISH THOMSON-HOUSTON CO., LTD.,
RUGBY E6651 A

SITUATIONS VACANT

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LIMITED

ARMAMENTS DIVISION

A Senior Engineer is required for work on Analogue Computers. Applicants should have a degree in electrical or mechanical engineering, and be thoroughly conversant with the theory of analogue computing. In addition a number of years' experience covering the design and use of computers of this type is required.

This is a senior position of considerable interest and responsibility, and it will offer ample scope to an Engineer well versed in the theory and practice of this type of work.

An attractive salary will be payable and a generous pension scheme is in operation.

All applications will be treated in the strictest confidence and you are invited to apply to:

SIR W. G. ARMSTRONG WHITWORTH
Technical Appointments Officer,
AIRCRAFT LIMITED,
BAGINTON, Nr. COVENTRY
Quoting reference: Comp/5.
E884 A

BILLINGHAM ICI DIVISION

MECHANICAL ENGINEERING DRAUGHTSMEN
and
CIVIL ENGINEERING DRAUGHTSMEN

There are vacancies with attractive salaries for each of the above classes of Draughtsmen at Billingham. Candidates must possess as a minimum qualification the appropriate Higher National Certificate or its equivalent. Participation in Staff Pension Fund and Profit-Sharing Scheme, and financial assistance towards removal expenses is available to married men.

Without commitment, write for application form to the Staff Manager, Imperial Chemical Industries, Limited, Billingham Division, Billingham, Co. Durham, quoting reference No. R.16.

IT IS SIGNIFICANT THAT A LARGE PROPORTION OF OUR STAFF REMAIN WITH THE COMPANY UNTIL RETIREMENT AGE. E835 A

Applications are invited from

SENIOR DESIGN AND DEVELOPMENT ENGINEERS

with an Engineering Degree or equivalent and experience on general mechanical design, for appointments with a leading general Engineering Company.

- *The appointments offer excellent prospects and a commencing salary in the range of* **£1,200 to £1,500** *per annum*

The appointments will be tenable in the London area and housing assistance will be given to applicants resident outside London.

- **Applications should be addressed to BOX No. E6642, "The Engineer"** A

DRAUGHTSMEN

SIMON-CARVES LTD.
have additional vacancies at their
MAYFAIR OFFICE
for experienced
MECHANICAL DRAUGHTSMEN

Working conditions are excellent. Starting salaries will depend upon qualifications and experience ; for senior men they will range up to £800 a year. A Pension Fund and non-contributory Pension Scheme are in operation. 5-day week. Three weeks' annual holiday. Interviews will be arranged in London. Apply, quoting Ref. SB4, to Staff and Training Division, Simon-Carves Ltd., Bird Hall Lane, Cheadle Heath, Stockport. E6677 A

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DRAWING & DESIGN SERVICE

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AGENCIES

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CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E575 MW

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THE PROPRIETOR of British Patent No. 650,577, for "IMPROVEMENTS IN AND RELATING TO SPEED CHANGE GEARS," desires to enter into negotiations with a firm or firms for the Sale of the Patent or for the Grant of Licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E6661 H

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LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E112 K

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NON-FERROUS FOUNDRY, near London, equipped for sand and die casting, machining. At present employing 30 people Room for expansion. To let as going concern.—Bl X No. E3809, "The Engineer." L

LONG-ESTABLISHED profitable Midland family Light Engineering and Millwrights' Business for sale due death, going concern. Audited accounts.—Apply in confidence, Moss, Toone and Deane, Solicitors, Loughborough. E6705 L

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Chartered Surveyors. Chartered Auctioneers an Estate Agents

In the centre of
KINGSTON-UPON-THAMES
FREEHOLD FACTORY
at present used as Engineering Works,
14 & 16 COWLEAZE ROAD,
SQ. 4130 FT.
(Mainly single storeyed).
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MACHINERY Etc. WANTED

COLES 5-ton or 6-ton Crane wanted. Lorry-mounted considered. Must be cheap.—BOX No. E6605, "The Engineer." P

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SURPLUS STOCKS
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Send details of your surplus to
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IMMEDIATE COLLECTION.
BEST PRICES. PROMPT PAYMENTS.
E690 P

Classified Advts. continued on page 10

MACHINERY, &c., WANTED

WANTED, all types of modern motorised Machine Tools. Offer your surplus to us and obtain the best prices.—Norman E. Potts (Birmingham), Ltd., 130, Moseley Road, Birmingham, 12. E123 F

WANTED, Heat-Treatment Oven, approximately 10ft. by 6ft. by 3ft., preferably gas fired, temperature up to 700 deg. C.—Please send full particulars price and location to Lightalloys, Limited, St. Leonards Road, London, N.W.10. E6719 F

FOR SALE

MERSEY RIVER BOARD

SALE OF 30FT. PILE DRIVING PLANT

QUOTATIONS are invited for the PURCHASE of 30ft. B.S.P. PILE DRIVING FRAME. The plant travels on 8ft. 11in. gauge rail track and is adjustable by screw jacks for raking piles and for use on banks with slopes up to 2 to 1. The plant is also equipped with 1-ton and 2-ton hand winches. Some parts are corroded due to storage in the open. Guy ropes and timber decking missing, otherwise complete. Drawing showing details of the plant is available on application. The dismantled plant can be inspected during normal business hours at the Board's Offices at "Mirwell," Carrington Lane, Sale, Cheshire. Quotations, in a plain sealed envelope marked "Pile Driving Plant," should be sent to the Engineer, Mersey River Board, at the above address, not later than Friday, July 20th, 1956.

A. H. JOLLIFFE,
Clerk of the Board.

Liverpool Road,
Great Sankey,
Warrington. E6648 G

600

STEAM-DRIVEN ALTERNATOR SETS

400/440/3/50, EACH WITH ACCESSORIES AND CONTROL GEAR

600kW. WEIR/E.E.C. Pass-Out Turbo Set, 150/190 W.P., 80 deg. F. superheat, back pressure 15 p.s.i.
500kW. BELLISS and MORCOM/E.E.C., Condensing Turbo Set, 190 W.P., 150 deg. F., passing out up to 10,000 lb. per hour at 60 lb. sq. in., balance to condenser, steam consumption 15,900 lb. per hour.
400kW. BELLISS and MORCOM/E.E.C., engine 565 b.h.p. compound, 115/150 W.P., 447 deg. F., exhausting to atmosphere/15 lb. sq. in. back pressure, 375 r.p.m.
250kW. DRYSDALE/HARLAND, engine 2-crank non-compound, 180/200 W.P., back pressure 30 lb. sq. in., 375 r.p.m.
150kW. BROWETT LINDLEY/BRUCE PEEBLES, engine compound, 160 W.P., back pressure 10 lb. sq. in., 428 r.p.m.
150kW. ASHWORTH PARKER/B.T.H., engine compound, 155 W.P., back pressure 5 lb. sq. in.

GEORGE COHEN,
SONS AND CO. LTD.
WOOD LANE, LONDON, W.12.
Tel.: Shepherds Bush 2070; and
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B.C.S.

Two 16/20 H.P. Ruston-Hornsby Diesel Locomotives, 24in. gauge, in first-class condition.

3, CASTLE STREET, CARDIFF.
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Nearly new 90-ton Electric Goliath Crane, 106ft. span, 72ft. lift, by Sir Wm. Arrol and Co., Ltd. Lattice steel construction throughout. Motors 100 H.P. hoisting, 45 H.P. cross traverse and 70 H.P. longitudinal travel, 400 volts, 3 phase, 50 cycles. Total weight about 300 tons. Perfect condition.

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TWW

NEW WOODHOUSE and MITCHELL 70 JUNIOR, 7in. S.S. and S.C. LATHE, elec. equip. for 400/440/3/50.
NEW WOODHOUSE and MITCHELL 85 HEAVY-DUTY 8½in. CENTRE LATHE, 12 spindle speeds, 21/945 r.p.m., motorised, three-phase supply.
SHANKS 19½in. CENTRES by 19ft. 6in. BETWEEN CENTRES, ALL-GEARED HEAD S.S. LATHE (not screw cutting), gap bed, two saddles, elec. equip. for 400/3/50 cycles supply.
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SWIFT 9in. centres by 70in. between centres, 2in. hollow spindle, 8 spindle speeds, 23/308 r.p.m., single pulley drive.

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E214 G

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RECONDITIONED
JONES MOBILE CRANES
SUPPLIED WITH A 3 MONTHS' GUARANTEE

Lorry-mounted, 4-ton Mobile Crane, comprising KL 44 on Foden DG 6/12 lorry chassis, 24ft. jib.
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JONES Super 12, capacity 12 cwt., on push travel chassis, steel wheels, Coborn petrol engine, standard type jib.
All Jones cranes supplied by us are covered by our after sales service and receive four free inspections during the first 12 months.

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NILES 52in., Single Column Vertical Boring and Turning Mill, Model DKES 1320.
NILES 57in., Single Column Vertical Boring and Turning Mill, Model DKES 1450.
NILES 6ft. 6in., Double Column Vertical Boring and Turning Mill, Model DKZ2000 × 1250.
NILES 13ft., Double Column Vertical Boring and Turning Mill, Model DKZ4000 × 2000.
Early delivery. Demonstration by appointment. Write for details.

DIMCO (GT. BRITAIN) LIMITED,
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OFFER FOR IMMEDIATE SALE:—

One 6-Ton Coles Model S.710 "Argus" Fully Mobile Crane with 30ft. jib, cab, Perkins P.4 engine, pneumatics, indicator, &c. New late 1955. In first-class condition. Available shortly.
One 5-Ton Smith Diesel Loco. Crane with 40ft. jib, dual gauge. New June, 1952. Power lowering little used.
Several Jones 3-Ton "Super 40" Diesel Mobile Cranes, 24ft. jibs, mounted on twin solids, Ruston engines. New 1947 approximately. With cabs. Completely overhauled.
One 3-Ton Butters Electric Derrick Crane, 100ft. jib. New 1949. In good condition.
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SOLE AGENTS FOR MORGAN—THE WORLD'S BEST DERRICK.

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ELECTRO HYDRAULIC FLANGING PRESSES 120 TO 500 TONS
Robust all welded construction incorporating the most modern developments.

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E869 G

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Two 250kW. new Diesel Generator Sets, by Laurence Scott, each consisting of a vertical 6-cylinder Paxman Ricardo diesel engine, type R.X., 750 r.p.m., direct coupled on bed-plate to a 220-volt D.C. generator, 1100 amps. Each set complete with spare parts.
Further details on request.

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TWW

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100 Tons New Perfect B.H. RAILS, 95 lb. yard, chiefly 60ft.
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About 120 complete TURNOUTS, 24in. gauge, made from 20 lb. F.B. rails, mounted on steel sleepers, 15/16ft. overall.
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WARD'S CAN SUPPLY NEW OR GOOD SECOND-HAND SLEEPERS, CHAIRED SLEEPERS AND CROSSING TIMBERS, CAST IRON CHAIRS, SWITCHES AND CROSSINGS, BUFFER STOPS, TURNTABLES, or, if preferred, CONCRETE SLEEPERS COMPLETE WITH SUITABLE FASTENINGS.

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E213 G

B.C.S.

One 600kW. Sulzer Diesel Generating Set, 220/440 volts, D.C., complete with auxiliaries, spares, &c.
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One 80kW. General Motors/Houchin Diesel Alternator Set, 400/440 volts, three-phase, 50 cycles, 1500 r.p.m., complete with all auxiliaries and switchboard.
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Two 20kW. Hill and Co./Delco Diesel Generating Sets, 120 volts D.C., 1450 r.p.m., complete with auxiliaries.

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100-ton Electric Overhead Travelling Crane, 100ft. span, power unit, wire rope and block for 180 tons. Span can be reduced for any required capacity up to 180 tons. 400 volts, 3 phase, 50 cycles.

REED BROTHERS,
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600

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Five new and unused FIELDING and PLATT Duplex Reciprocating Pumps, type SPA–16, designed for handling oil or water, capacity 430 g.p.m. at 1200 p.s.i., belt drive.
2000 g.p.m., 240ft. hd. MATHER and PLATT 2-Stage Pump, with 235 h.p. Harland motor, 400/3/50.
Two 2000 g.p.m., 150ft. hd. ALLEN CONQUEROR Pumps, with 135 h.p. Laurence Scott motors, 400/3/50.

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Tel.: Pudsey 2241. E202 G

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Black Bolts and Nuts, 4in. by ⅞in., Csk. Rd. Hex.—2½ tons.
Immediate Delivery.
TODD BROS.
(ST. HELENS AND WIDNES), LTD.,
ST. HELENS, LANCASHIRE.
E6716 G

BAR TURNING MACHINES

Farmer Norton Centreless Bar Turning Machines, capacity 4in. M.D. 400/3/50, with various cutter heads, in and out feed bogies.—H. BELL (MACHINE TOOLS), LTD., Walter Street, Leeds, 4 (Tel., 63–7398). E185 G

DAVY PAXMAN ENGINE 12 r.p.h., 400 h.p., 1000 r.p.m., series 1, coupled to a 330kVA., 264kW., 3-phase, 50 cycle, 400/440 volt, B.T.-H. Alternator. Engine and Alternator mounted on a combined base-plate. Separate switchboard by G.M. Eng. Co. Year of manufacture 1947. Cost price £7500. Very good condition—for quick disposal would accept £2000.—Apply, Collaro, Ltd., Ripple Works, Bypass Road, Barking, Essex. E6695 G

FOR SALE, One 3in. "Ajax" Horizontal Forging Machine, by Greenwood and Batley. First-class condition. Nearest offer to £3000.—Apply to The Superheater Co., Ltd., Mosley Road, Trafford Park, Manchester, 17. E6692 G

FOR SALE

SERVICE EDWARDS VALUE!

LEE & CRABTREE Eccentric Horning and Punching Press, rise and fall table, motorised 400/3/50, pressure 30 tons, stroke 3½in., centre to back 7in. Seen at Birmingham.
BESCO Universal Folding Machine, mounted on cast iron legs, capacity 40in. by 18 s.w.g., complete with blades for sharp and round bending.
New BESCO Production, Open Ended, Overcrank Guillotine, Model 48/25, motorised automatic hold-down, all gauges, capacity 48in. by ¼in. mild steel, gap depth 6in.
New BESCO Universal Swing Beam Box Forming and Folding Machine, Type F, capacity 40in. by 11 gauge, max. lift of beam 6in., suitable for forming trunks, channels, trays, mouldings, &c.
New TRUMPF Electric, Throatless Shearing Machine, Model OMS 401/402, bench mounting, motorised 400/440/3/50, capacity 7 s.w.g. mild steel, suitable also for polishing, grinding, fettling, wire-brushing, &c.
BURFREE No. 2 Nibbling Machine, on stand, motorised 400/440/3/50, capacity ⅛in. mild steel, ⅛in. stainless steel, gap depth 12½in.
Photographs of the above are available.
MACHINE TOOLS, NEW AND USED.
Of Every Description. Attractive Prices.

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Telephone: EUSton 4681–3771;
and at
LANSDOWNE HOUSE, 41, WATER STREET,
BIRMINGHAM, 3.
Telephone: Central 7606–7. E209 G

600

AIR COMPRESSORS

Two 2500 c.f.m. ALLEY and MACLELLAN, 15 p.s.i., with 200 h.p. Laurence Scott motor, 400/440/3/50, also aftercooler and air receiver, 6ft. diam. by 23ft.
724 c.f.m. TILGHMAN FC9AM, 30 p.s.i., with 90 h.p. Brook motor, 400/440/3/50.
499 c.f.m. HICK HARGREAVES RCA11A, 10 p.s.i., with 35 h.p. Brook motor, 400/3/50.

GEORGE COHEN,
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STANNINGLEY, Nr. LEEDS.
Tel.: Pudsey 2241. E204 G

FOR SALE

FARMER NORTON 4in. Centreless Bar Turning Machines.
CINCINNATI 16in. by 48in. Plain Cylindrical Grinder. Filmatic bearings.
ASQUITH 4ft. 6in. O.D.1. Radial Drill. With box table.
NEWALL 420 Universal Thread Grinder, with relieving, internal grinding and automatic diamond wheel dressing attachments, &c.
WARD HAGGAS & SMITH A.G.H. Faceplate Lathe. Swings 71in. dia. and 48in. length.
KITSON DORIN Heavy Duty Axle Turning Lathe, 11in. centres, 7ft. between.
HERBERT No. 9 Combination Turret Lathe. Spindle bore 4 ⅛in.
CINCINNATI 3/36 Plain Hydromatic Miller. Table overall 60in. by 14in., hydraulic traverse 36in., with feed variator.
TAYLOR & CHALLEN Type 1281 Geared Power Press. Cap. 75 tons.
CLIFTON & BAIRD Model ACS 24in. Fully Automatic Cold Saw. Cap. 8in.
CINCINNATI No. 3 Dial Type Vertical Miller. Table 62½in. by 15½in., quick power traverse all ways, speeds to 450 r.p.m.
CHURCHILL FAY 12in. by 45in. Automatic Lathe, A.G.H. Quantity equipment.
These and many other modern motorised machine tools available ex stock. from:—

H. BELL (MACHINE TOOLS), LTD.,
WALTER STREET, LEEDS, 4.
Tel.: 63–7398. E185 G

B.C.S.

One 1500kW. Brush Ljungstrom Turbo Alternator Set, 6600 volts, three-phase, 50 cycles, 0·8 P.F., W.P. 200 lb. p.s.i., complete with auxiliaries.
One 3000kW. Brush Ljungstrom Turbo Alternator Set, 6600 volts, three-phase, 50 cycles, 0·8 P.F., W.P. 200/250 lb. p.s.i., complete with auxiliaries.

3, CASTLE STREET, CARDIFF.
Tel.: Cardiff 29246. E6279 G

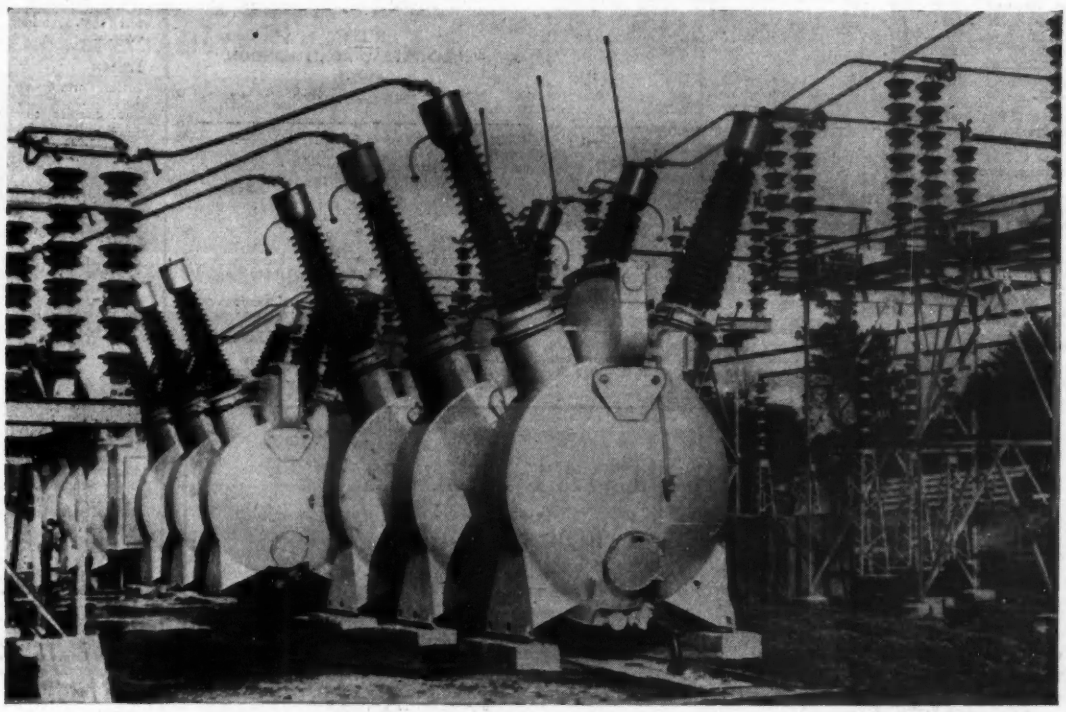
DRILL JIG BUSHES for disposal at attractive prices. Tool steel, internally lapped and externally ground for press fit.
8000 off ⅜in. by ⅝in. by ½in. long.
5000 off No. 13 by ½in. by ¾in. long.
1000 off ¼in. by ⅜in. by ½in. long.
3000 off ⅜in. by ½in. by ¾in. long.
4500 off ½in. by ¾in. by 1in. long.
1000 off ⅝in. by 1in. by 1½in. long.
Samples on request. Offers.—BOX No. E3860, "The Engineer." G

FOR SALE, two Hunslet Locos., type 0–6–0 saddle tank, coal fired, W.P. 160 lb., 4ft. 8½in. gauge; No. 1672, year 1914, with 1935 boiler; hydraulic test 1949; requires attention. No. 1661, year 1917, with 1946 boiler, hydraulic test May, 1956. In running order. Location Essex. Offers by 10th July.—BOX No. E6673, "The Engineer." G

Classified Advts. continued on page 12

220-kV CIRCUIT-BREAKERS

for the State Electricity Commission Victoria



Sixteen 220-kV, 5,000-MVA Shuntarc oil circuit-breakers have been ordered by the State Electricity Commission, Victoria, Australia. The illustration shows the installation at Yallourn power station where six of the circuit-breakers are already in commission.

Super-tension BTH 'Shuntarc' circuit-breakers are in service in many parts of the world; a recent order from the British Columbia Electric Company covers six 230-kV, 7,500-MVA units.

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FOR SALE

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TURBO-ALTERNATOR SETS

3750kW. MET.-VICK. Condensing Geared Turbo Set, with boiler, 200 p.s.i., 550 deg. F., 6600/3/50, surface condenser, ancillaries, switchgear, boiler. Stirling type Tri-Drum water-tube, 200/210 p.s.i.

2500kW. B.T.H. Condensing/Pass-Out Set, 250/255 p.s.i.g., 610/630 deg. F., can operate fully condensing 28·5in. HG. or pass out 15,000/55,000 lb. steam per hr., 18/35 p.s.i. alternator 440/3/50.

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SONS AND CO. LTD.
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Tel.: Shepherds Bush 2070 ; and
STANNINGLEY, Nr. LEEDS.
Tel.: Pudsey 2241. E205 G

FOR SALE

HT.4 Caterpillar Tractor Shovel, 1½ cu. yd. bucket.
Jones KL.44 Diesel, 30ft. jib, on pneumatics.
5-ton Ransomes and Rapier Super Pet./Elec. Mobile Crane on solids.
6-ton Ransomes and Rapier Standard Pet./Elec. Mobile Crane on solids.
6-ton Ransomes and Rapier Super Pet./Elec. Mobile Crane on solids.

WILLIAM G. SEARCH LIMITED
WHITEHALL ROAD, LEEDS.
Tel.: 639081. E6669 G

CRANE

3-ton Rapier Super Mobile Diesel-Electric Crane, full slewing on pneumatics. As new.

JOSEPH PUGSLEY & SONS, LTD.
BRISTOL, 5.
Tel.: Bristol 56037. E6702 G

B.C.S.

22,000 Babcock and Wilcox C.T.M. steel-cased Water Tube, 260 lb., with Superheater, Economiser by Green, Chaingrate Stoker. All mountings.

15,000 Babcock and Wilcox C.T.M. type Water Tube, 180 lb., with Superheater, Economiser by Green. All mountings.

Two 14,000 John Thompson 4-Drum Water Tube, 250 lb., with Senior Economiser. All mountings.

30ft. by 8ft. 6in. Lancashire, by Yates and Thom, 60 lb. All mountings.

3, CASTLE STREET, CARDIFF.
Tel.: Cardiff 29246. E6280 G

600

DIESEL ALTERNATOR SETS

Quantity MIRRLEES, BICKERTON and DAY vert., 4-stroke, air-start Diesel-driven Alternator Sets, 400/440/3/50, as follows :—

Qty.	kVA	Type	Speed	Alternator
1	75	UA.3	600	L.D.C.
1	94	UA.3	600	Met.-Vick.
1	100	UA.4	600	G.E.C.
1	147	ULA.5	500	L.D.C.
2	155	ULA.5	500	Met.-Vick.

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'PHONE 98 STAINES

Three 13,000 gall., 15ft. by 12ft. deep, Cyl. Enc. Tanks.
Three 12,000 gall., 30ft. by 9ft. Cyl. Enc. Tanks.
Three 7000 gall., 30ft. by 7ft. (Bitumen) Tanks.
Two 4800 gall., 12ft. by 8ft. by 8ft., Sec. Tanks.
Twenty 600 gall., 5ft. by 4ft. by 5ft., Rec. Tanks.
Seven 600 gall., 5ft. by 5ft. 6in., Cyl. Pressure Tanks.
50kVA. Diesel Generator, 440/3/50.
78 h.p. Ruston Diesel 3 cyl., horiz.
Mixers, Autoclaves, Pumps, Hydros, Ovens, Refiners, Conveyors, Steam Engines, &c.

HARRY H. GARDAM AND CO., LTD.
E101 G

FOR SALE, PONTOONS, measuring 35ft. by 13ft. 6in. by 6ft., 5 watertight compartments, fitted manhole covers, mild steel construction.—R. S. Hayes, Ltd., Jenkins Yard, Bridgend (Tel. No. Bridgend 1311/2). E867 G

FOR SALE

FRED WATKINS (BOILERS), LTD.

RECONDITIONED MACHINERY FOR SALE

STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic, 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia. 150, 180 and 200 lb. w.p.; 30ft. by 9ft. by 200 lb. w.p. Lancashire ; 300 reconditioned Vertical Crosstube, all sizes.

AIR COMPRESSORS.—Ingersoll-Rand 200/300 cu. ft.; Worthington DA36 325 cu. ft.; Broomwadé D23, 200 c.f.m.; Broomwade D22, 130 c.f.m.; all motorised, 100 lb. pressure.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

CRANES.—8½-ton Ransomes Diesel, pneumatics, 1952 ; 6-ton Coles Diesel-Electric ; 3-ton Jones Diesel, track mounted, 24ft. jib ; ten Neal's 2-ton Diesel, 20ft. jibs ; 5-ton Taylor Steam Loco., 40ft. jib ; E.O.T. Cranes, 2-ton Butters, 3-motor, span 42ft. (2) ; 7½-ton King, 1950, 43ft. span ; 5-ton Butters Electric Derrick, 90ft. jib, new 1948, with travelling bogies.

RAILWAY MATERIAL.—Bagnall 0-4-0 Steam Loco., 14½in. by 22in.; Peckett 0-4-0 Loco., 7in. by 22in.; Three miles 20 lb. Track, 24in. gauge, bogies, turnouts, locos., &c.

STEEL PIPING.—100 tons ½in. to 6in. screwed, 2000ft., 8in.; 10,000ft., 6in. flanged and Victaulic ; Flexible Pumping Hose, 4in., 8in., 10in. bore ; flanged as new.

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VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock, all sizes, Parallel Slide Sluice, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—Five 30ft. by 9ft. welded ; ten Boiler Tanks ; 50 dish ended 8ft. 6in. by 5ft. 6in. dia. Over 300 vessels in stock.

SLING ENGINEERING WORKS,
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'Phone : Coleford 2271/2. E366 G

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Three Little Used GAS PRODUCER PLANTS by Incandescent, capacity each 15,000 cu. ft. hr., with all staging, hopper, fans and electrics.

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Tel.: Shepherds Bush 2070 ; and
STANNINGLEY, Nr. LEEDS.
Tel.: Pudsey 2241. E200 G

1500 H.P. Rolling Mill Motor by B.T.-H., 3300 volts, 3 phase, 50 cycles, 211 r.p.m., with reversing controller. Also Reduction Gear, 5·33 to 1.—BOX No. E6501, "The Engineer." G

FOR SALE

CRANES

4-TON STOTHERT AND PITT PORTAL CRANE, 4 tons capacity on any radius between 18ft. to 35ft., fitted with Barnard double rope grab.

AABACAS GOLIATH CRANE, 4½-ton, 32ft. span, all-electric, 400 volts, three-phase, 50 cycles.—Full details, F. C. LARKINSON, Ltd., 39, Hitchin Street, Biggleswade, Beds (Tel., Biggleswade 2391/2/3/4) E6376 G

600

DIESEL ALTERNATOR SETS

1250kVA. GENERAL MOTORS/ELECTRIC MACHINERY, engine model 16/278A, 16 cylinder, 2 stroke, air start, 750 r.p.m., alternator 420/3/50.

250kVA. DEUTZ/SIEMENS SCHUCKERT, engine 290 h.p., vertical, 7 cylinder, 4 stroke, air start, 500 r.p.m., alternator 6300/3/50.

600kVA. BRITISH POLAR/A.S.E.A., engine vertical, 5 cylinder, 2 stroke, air start, 250 r.p.m., alternator 440/3/50.

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FOR SALE, Two 500kW Rotary Converters, by Metropolitan-Vickers, each comprising the following in excellent condition and insured.

Converter input 550kVA, 11kV, three-phase, 50, cycles.

Converter output 500kW, 210/220 volts D.C., two-wire.

Incoming 11kVA high tension O.C.B.

Starting panel.

D.C. output panel with circuit breakers, knife switches, positive, negative, equaliser, shunt regulator, unit meter, voltmeter and reverse relay.

Quantity of low-tension, D.C. cable, single core.

Both converters can be seen working.

BOX No. E6657, "The Engineer." G

NO. 42 Impulsator Multi-Vane Forward Curved Fan for belt drive, 30,000 c.f.m. at 545 t.p.m. Full details.—BOX No. E6664, "The Engineer." G

FOR SALE

FOR IMMEDIATE DISPOSAL

ITEM 1

Sixteen four-stage, high-pressure Air Compressors manufactured by Peter Brotherhood, Ltd., and Reavell & Co., Ltd. Each set comprises : Four-stage, high-pressure, air compressor, capacity 17·5 cu. ft. at 4000 lb. p.s.i. in 60 mins. at 500 r.p.m. Direct-coupled to 4¾in. by 7½in. by 6in., 2-crank, compound steam engine. Both engine and compressor mounted on common bedplate. These sets are complete with all gauges, piping, &c., and are New, Unused.

ITEM 2

One Hand-operated Overhead Travelling Crane manufactured by The Wharton Crane and Hoist Co., Ltd. Complete with 2 girders, traveller and hoist. 5 tons capacity. New, Unused.

ITEM 3

Two Salvage Pumps, each with an output of 250 tons per hour, 8in. suction and delivery. The pumps are direct-coupled to radiator-cooled petrol engine. These sets are complete with suction hoses and foot valves. Both pumps and engines are mounted on portable bedplates. Pumps manufactured by Sigmund. Used but in sound condition.

ITEM 4

One Portable Air Compressor. Capacity 17·5 cu. ft. at 3500 lb. p.s.i. Compressor direct-coupled to Crossley Petrol/Paraffin Engine and mounted on common bedplate. New, Unused.

ITEM 5

One Marine Type Crane manufactured by Stothert & Pitt, Ltd. Total weight 33 tons. Works throughout 360 degrees radius. Length of jib 61ft. Max. working radius 55·5ft. Min. working radius 20ft. Drifts of load 82ft. Tail radius 6·25ft. Hoist speeds : 5·36 tons at 100ft. per min., 7 tons at 80ft. per min. Slewing speeds 120ft. per min. Topping speeds 20ft. per min. Complete with 54 H.P. hoist motor, slewing motor 4/13 H.P., topping motor 25 H.P., 220 volts D.C. This Crane will lift 6 tons at 55ft. radius. Absolutely New, Unused.

ITEM 6

One Steam Crane manufactured by Joseph Booth Bros., Ltd. This Crane lifts with prop jacks extended : 5 tons at 16ft. radius to 1½ tons at 30ft. radius. Free on rails 3 tons at 16ft. radius to 1 ton at 25ft. radius. Length of jib 38ft. Rail gauge 4ft. 8in. Total weight 32 tons. Length of base carriage 21ft. Maximum width 8ft. 6in. Height 14ft. Condition almost equal to Brand New, Unused.

ITEM 7

Four Marine Diesel Engine-driven Generating Sets, each comprising : English Electric supercharged diesel engine, type 6SH, vertical, 6 cylinders, approx. 175 cwt. 1000 r.p.m., 275 cwt. 1500 r.p.m., direct-coupled to 150kW., 220-230 volt D.C. shunt wound Generator. Both engine and generator mounted on common bedplate. Absolutely New, Unused.

ITEM 8

Punching and Shearing Machine (Bennie). Shears 2in. thick H.T. or Nickel Steel plate, punch 2in. diameter holes. Complete with 2 jib cranes, capacity 4 tons at 20ft. radius, fully motorised, 440 volts D.C. Used but in sound condition.

BOX No. E3855, "The Engineer." G

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18¼ miles second-hand Railway Track, ex Main Line, comprising 2000 tons second-hand re-layable Bullhead Rails, 85 lb. per yard section, lengths chiefly 45ft., with all accessories. Good second-hand re-layable Chaired Sleepers to suit.

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E6564 G

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4 Tool Heads
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TRAVERSING HEAD SHAPER
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E210 G

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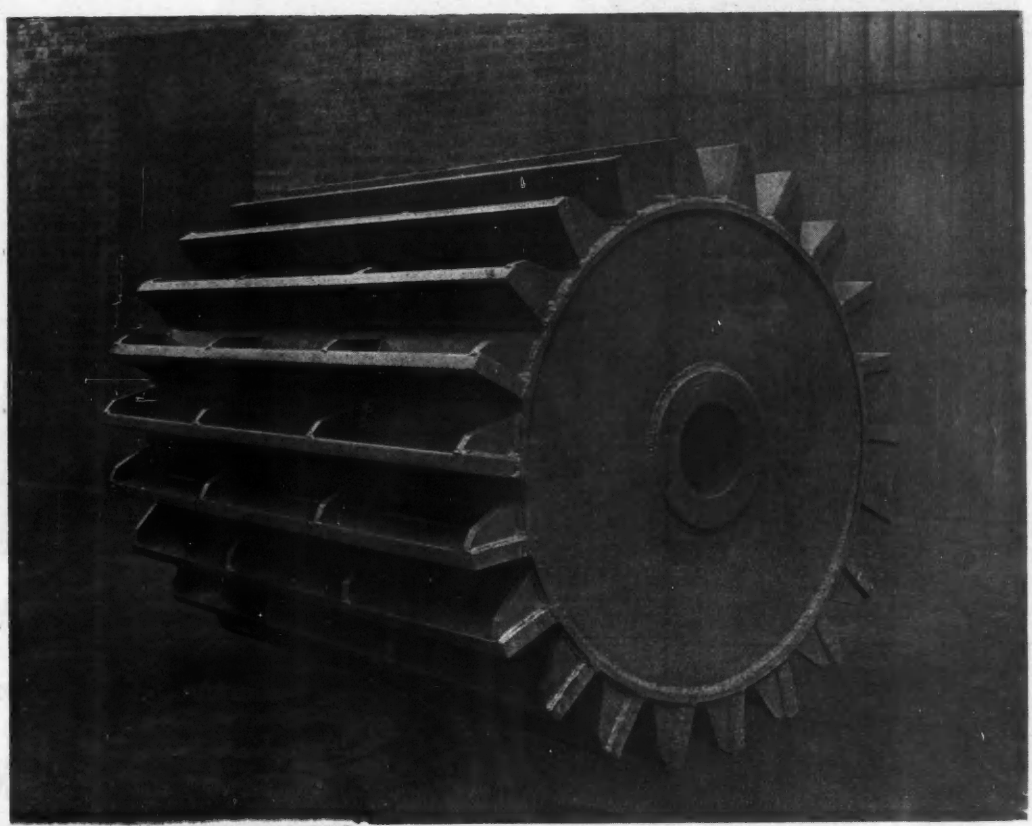

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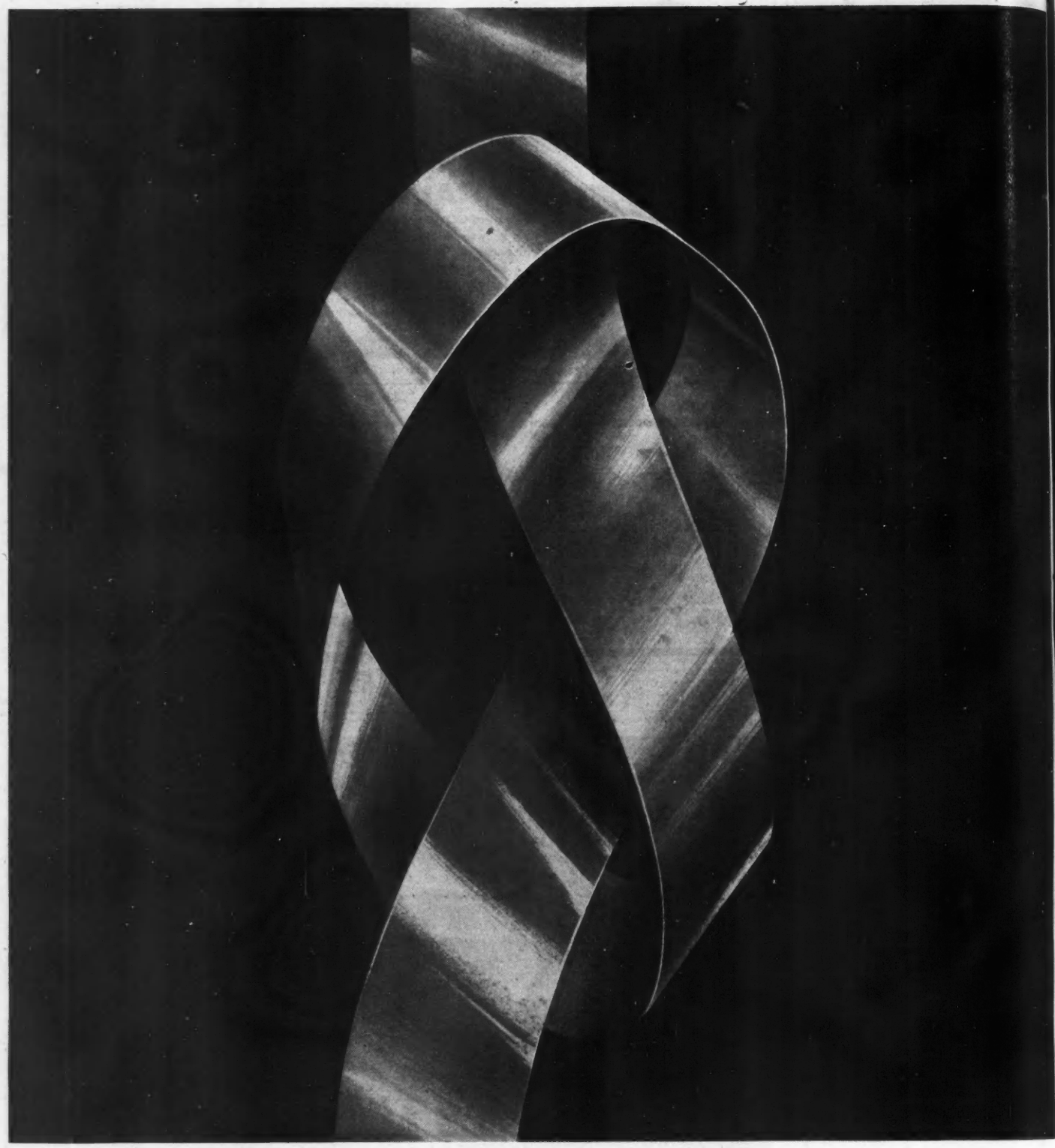

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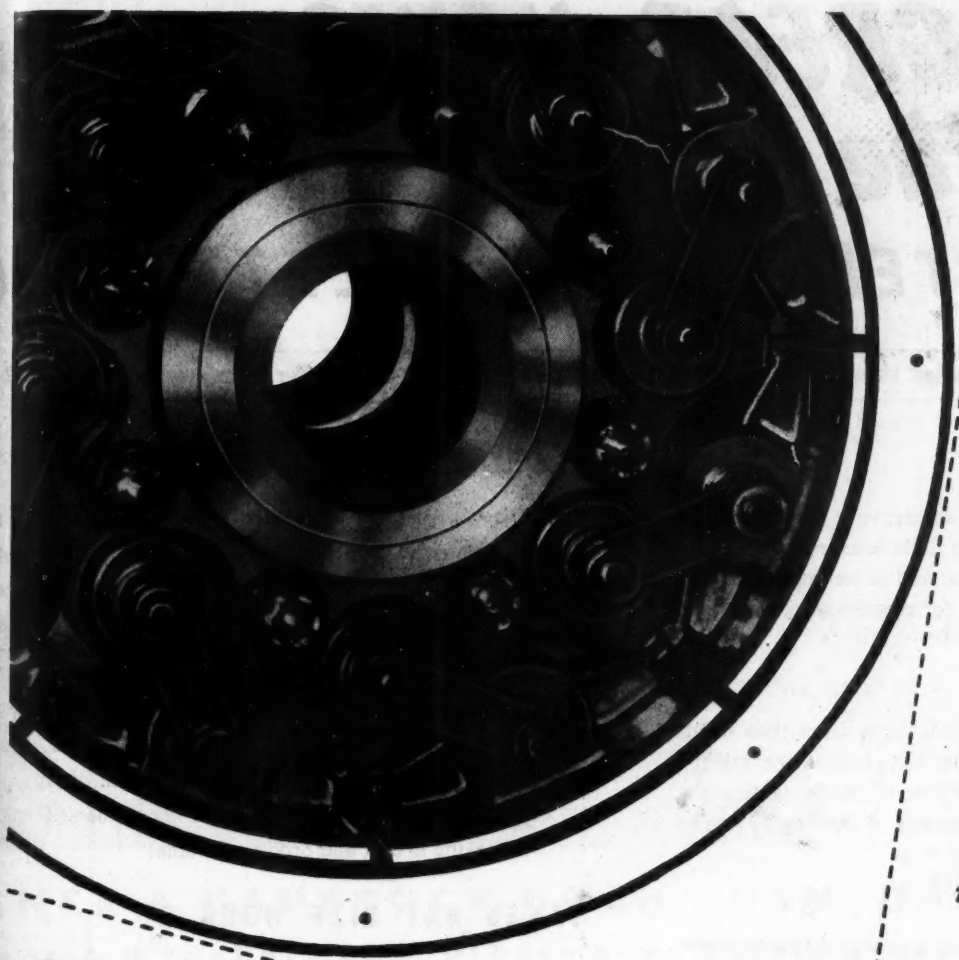

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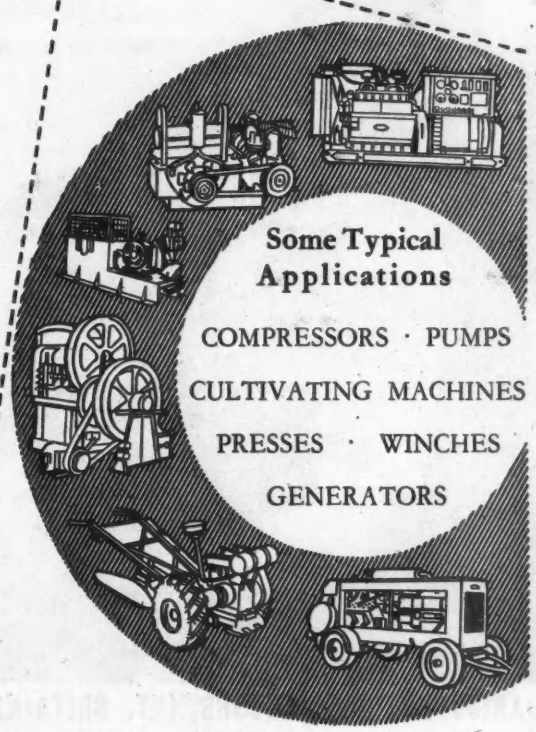

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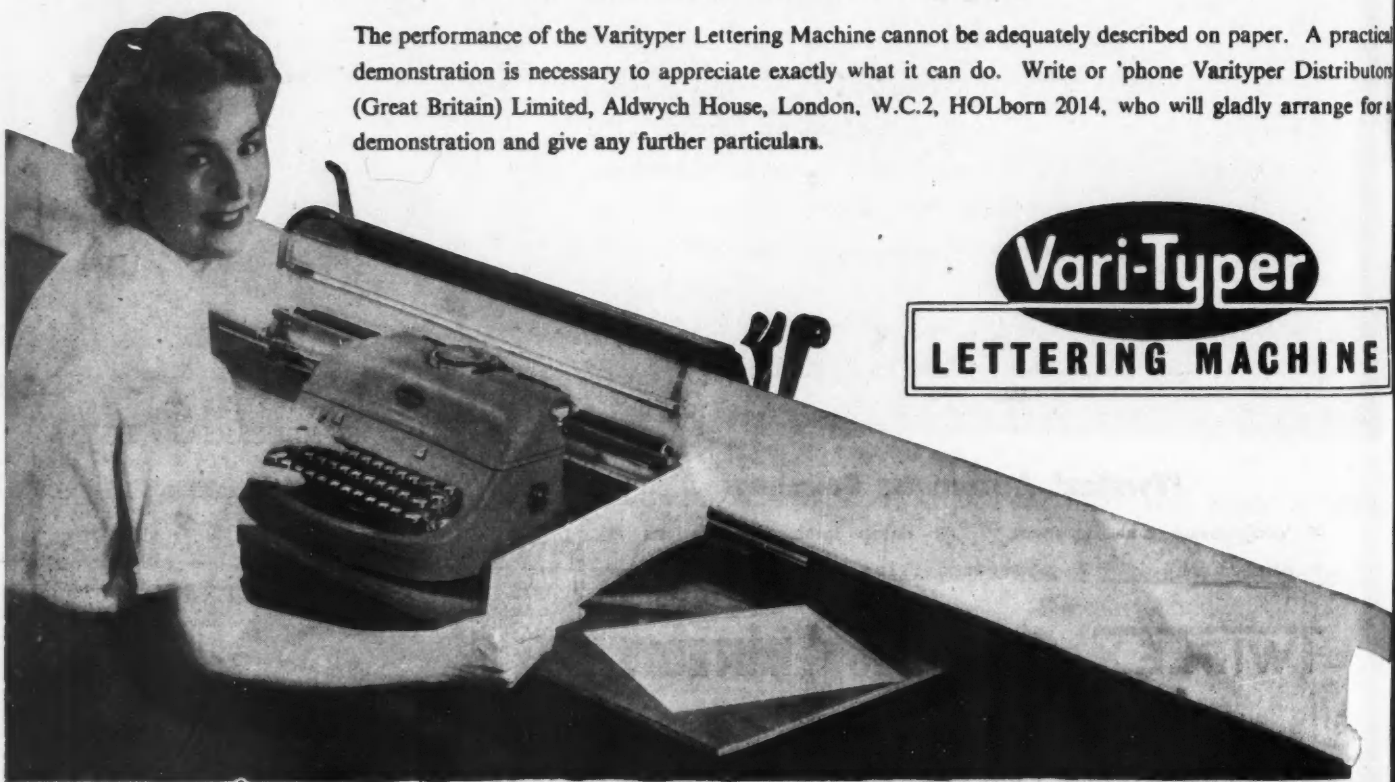

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MENCK PILE DRIVING PLANTS

DATA		MR 18	MR 27	MR 40	MR 60
Total height	abt.	74′ 3″	85′ 1″	97′ 11″	113′ 2″
	ca. m.	22,64	25,93	29,85	34,50
Useful height	abt.	57′ 5″	67′ 3′	78′ 9″	91′ 10″
	ca. m.	17,50	20,50	24,0	28,0
Permissible load (hammer plus pile)	lbs.	13,660	21,000	30,850	48,500
	kg.	6200	9500	14000	22000
Construction weight incl. standard boiler less hammer	abt. lbs.	47,685	67,980	97,900	146,600
	ca. kg.	21675	30900	44500	66500

Experts say that there are no better in the world

Quick and simple assembly

Maximum stability

The leader is separated from the frame

Can be used as ramming- and ordinary crane

Pile driving at great substantial rakes

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and a difficult BARIMAR welding job stands up to it still!

When Barimar welding goes out with the repair tag, that tag is the customer's guarantee of first-class workmanship. He knows it, and Barimar knows it too. Many a time, as in this particular instance, a customer refers to one of Barimar's long-ago jobs—to the fact that the repair continues to give splendid service.

Several years ago there came to Barimar a discing press body, weighing about seven-and-a-half tons and measuring 14 ft. by 4 ft. by 4 ft. The press was being used for pressing out the thick rim at the base of metal cases or canisters. This weighty casting was fractured through a heavy section of metal behind the big projecting lug—a portion subjected to tremendous strain. The damage was so grievous that production was almost at a standstill. Barimar was asked to tackle it straight away. First, the large boss was re-aligned, then soundly welded by Barimar experts in handling heavy castings. The highly-stressed part was built up and similarly reinforced, with the result that the casting emerged stronger than ever. An exacting repair, it was completed in less than a week, covered by the famous Money-Back Guarantee, and cost infinitely less than a replacement—even had a replacement been possible at short notice.

When a Barimar engineer recently discussed another repair with this customer, the seven-and-a-half tonner was proudly shown to him by the firm's Chief Engineer. The press, he declared, was continuing to give excellent service, the repair had more than come up to their expectations. The Barimar Guarantee had once more vindicated itself as the hallmark of British Scientific Welding craftsmanship.

7½-TON DISCING PRESS—the fracture that stopped production!

Repaired under Barimar Money-Back Guarantee several years ago —still going strong!

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Telegrams: "Bariquamar, Walgreen, London."

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● A considerable proportion of Barimar's welding work comes from the recommendation of satisfied customers. They appreciate the day-and-night service that is theirs to command, the promptness and inexpensiveness of Barimar guaranteed repairs.

● ALL BROKEN PARTS which are transportable must be sent CARRIAGE PAID or delivered to the nearest Barimar Branch. Please remove all fittings and post letter advising dispatch. When it is impossible to transport damaged machinery, Barimar experts operate ON THE SPOT

BARIMAR — THE WORLD'S SCIENTIFIC WELDING ENGINEERS

B

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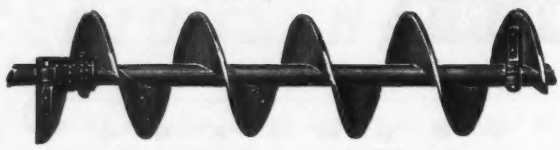

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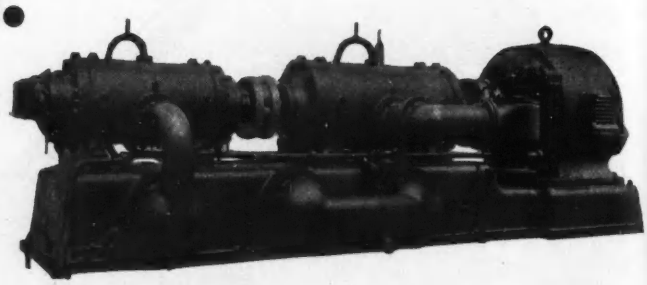

are made in varying sizes and capacities to meet all requirements and conditions of service, also for continuous day and night duty. Capacities : 3 to 8000 cu. ft./min.

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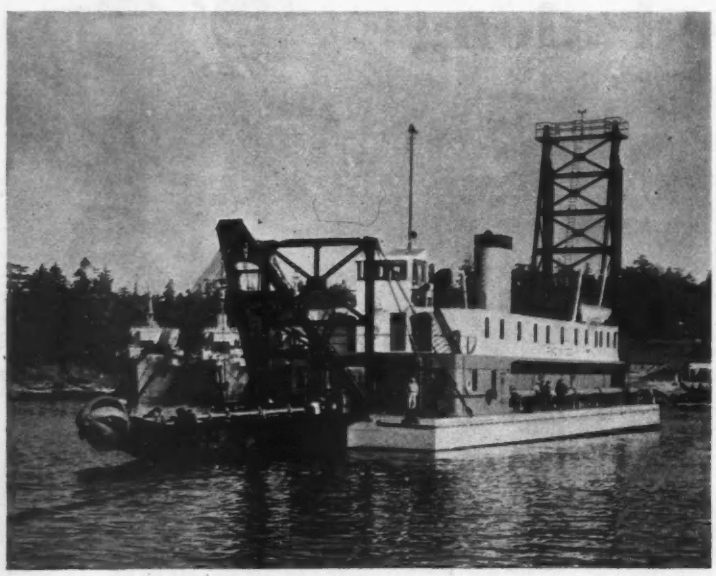

A cutter in Canada

A recent Lobnitz contract was in respect of the dredging machinery for this 20" suction dredge supplied to the Public Works Department, New Westminster, Canada.

Throughout the world, Lobnitz Dredges are famous for their reliability, fitness for purpose and economical working.

The hull of the vessel shown was built by Yarrows Limited, Victoria, B.C.

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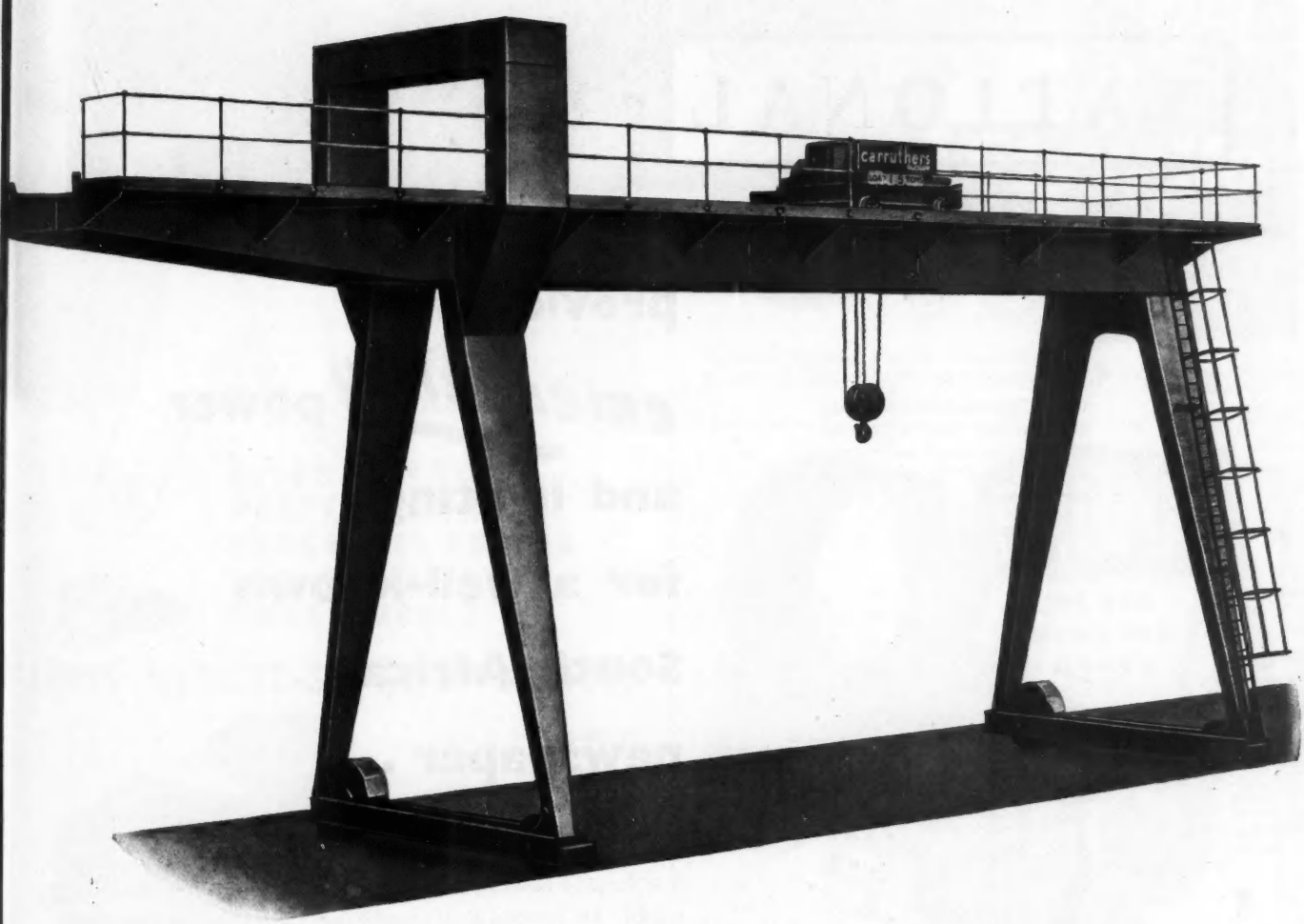

A typical medium capacity "Goliath Crane" supplied recently to an electricity authority.

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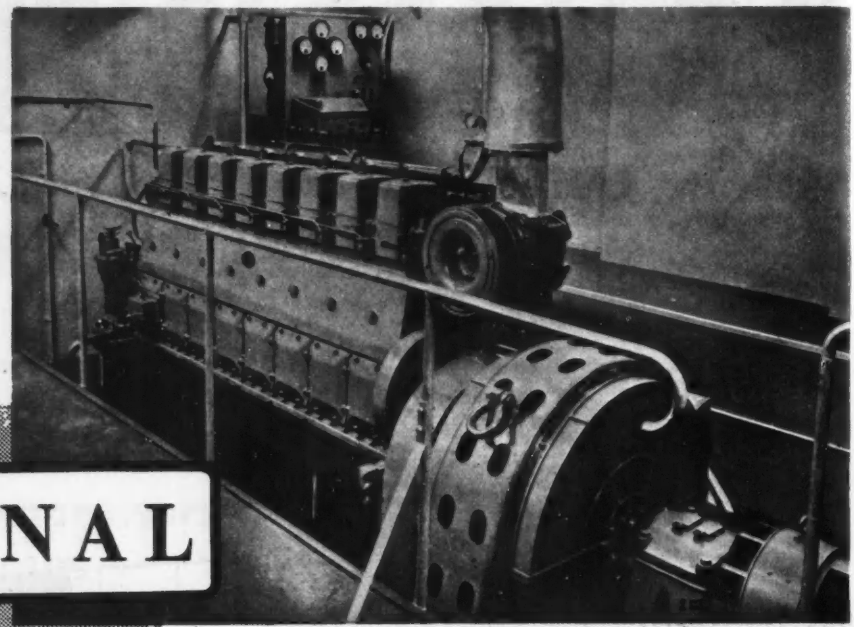
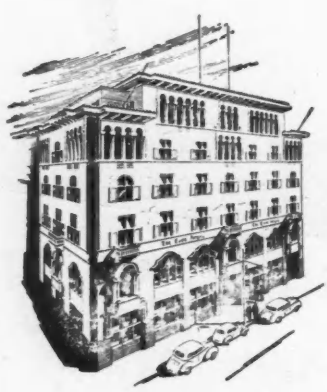


NATIONAL diesels

In the 'Cape Argus' newspaper printing plant, a National "R4AU8" type 660 b.h.p. pressure charged diesel engine drives a 500 kVA alternator for emergency supply.

provide *emergency* power and lighting for a well-known South African newspaper . . .



Argus Building, Cape Town

Whatever happens, that daily miracle, the newspaper, must go to press! It is therefore especially important to guard against failure of electric supply. The National diesel engine is particularly suited for emergency use in these conditions, as it can be started up at very short notice and will provide power and lighting at economic cost.

"The Cape Argus" relies upon National diesels as a safeguard in emergencies.

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PATENT APPLIED FOR

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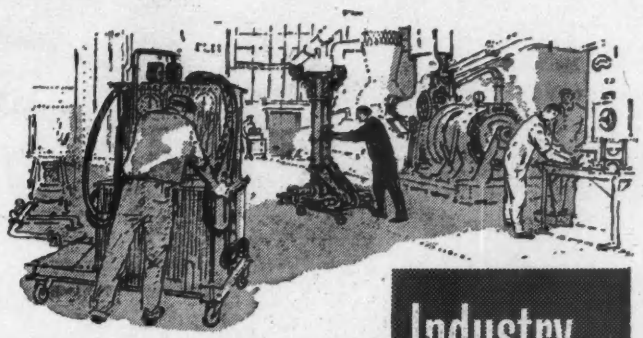

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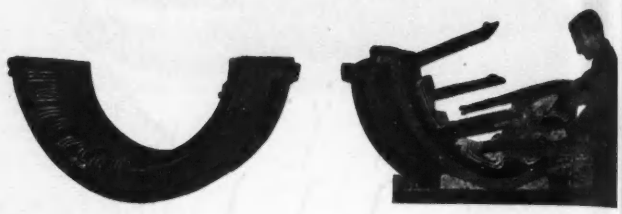

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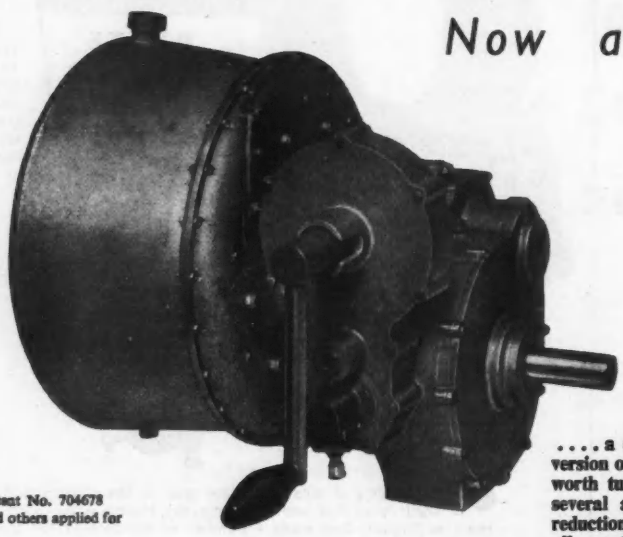

Patent No. 704678 and others applied for

....a 45/60 h.p. version of the Budworth turbine with several alternative reduction gears for all portable and other power requirements.

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These hand-started gas turbines are without electrics, will burn diesel oil, paraffin, or petrol without alteration, have the highest power/weight ratio of any small gas turbine, and need virtually no maintenance.

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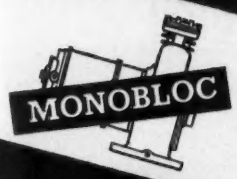

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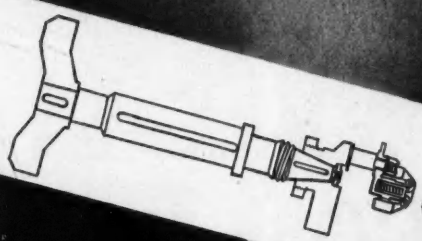

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Motor and compressor unit are mounted on a single shaft ensuring perfect alignment at all times. The use of ball and roller bearings reduces wear to a minimum and economy is assured by the low initial cost, low power consumption and negligible maintenance.
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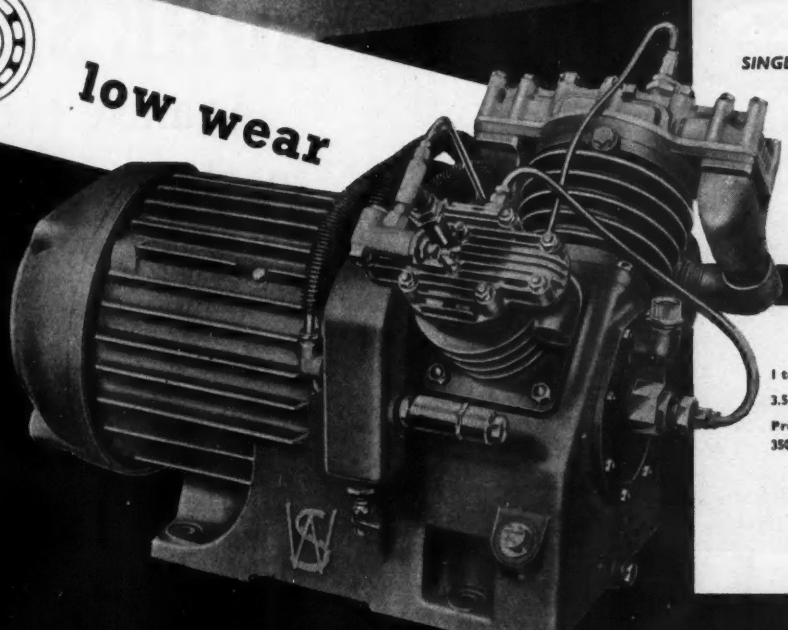

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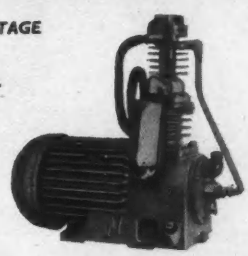

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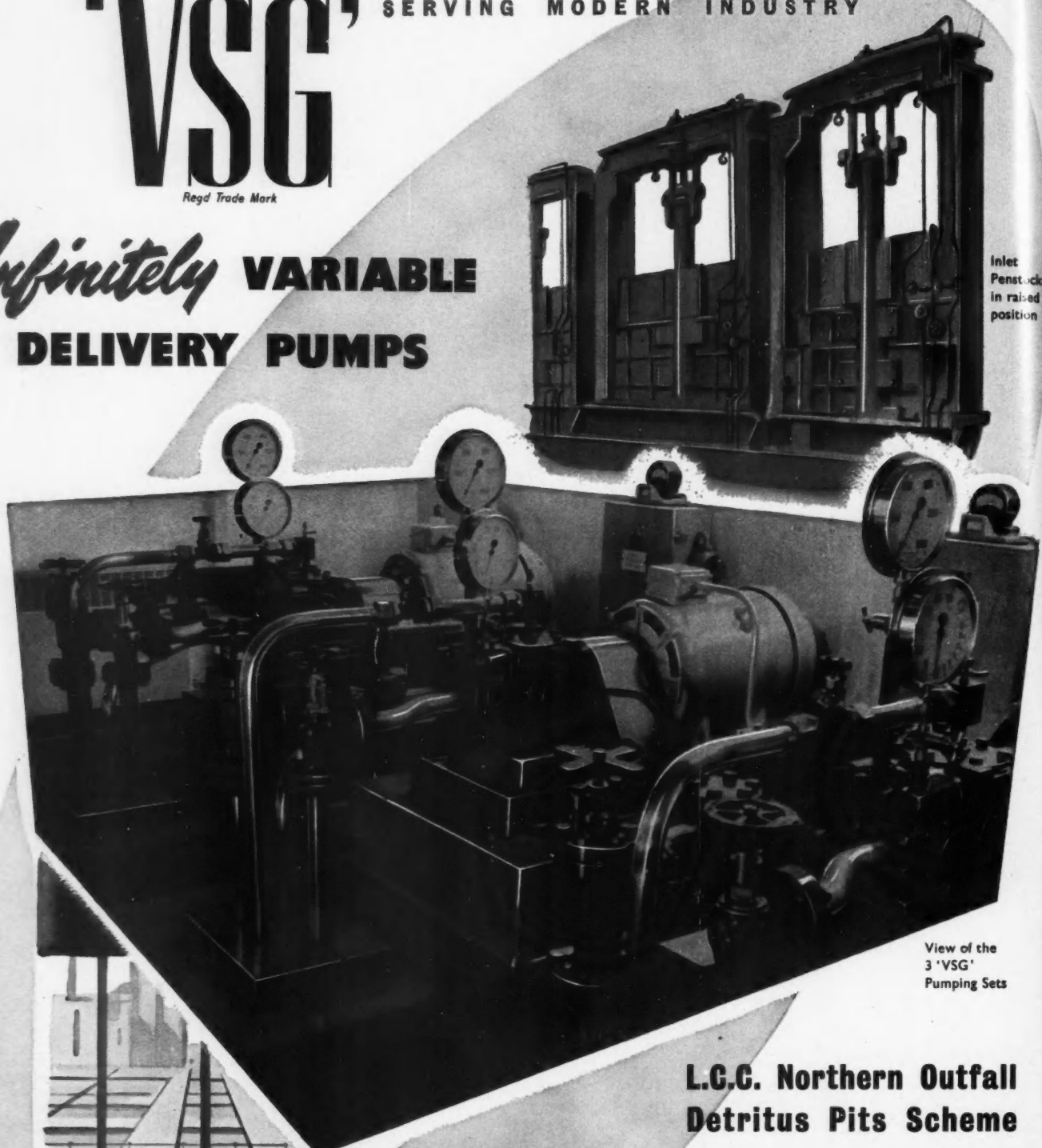
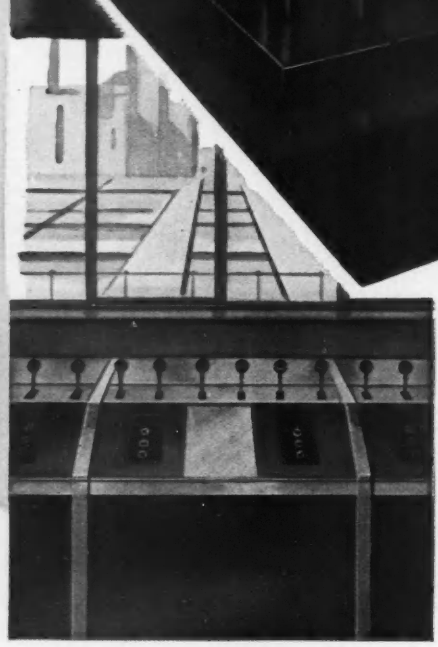


Inlet Penstocks in raised position

View of the 3 'VSG' Pumping Sets



View from control house overlooking inlet penstocks: control desk in foreground

L.C.C. Northern Outfall Detritus Pits Scheme

This scheme handles 200 million gallons of sewage per day. The layout consists of six Detritus Pits each having an inlet and outlet channel with the flow controlled by hydraulically operated penstocks. The pumping equipment consists of 'VSG' hydraulic auto pumps, storage tanks, control valves and operating desks. 'Holding' pressure on ram can be maintained over long periods and a source of high pressure oil is constantly available. Each penstock is desk operated by valves for raising, lowering and suspending. These three operations can also be carried out by hand at penstocks.

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A great new partnership! Arpic Engineering—one of the foremost manufacturers of portable compressors—is now a part of the Atlas Copco Group of Companies. This will result in the

mutual pooling of production resources and technical ideas, and in the increase of existing world servicing facilities. Read on, about the advantages this will bring you....

Turn to next page

Now that Arpic are part of the Atlas Copco Group you will be able to choose a compressor from one of the biggest ranges of portables in the world

Atlas Copco manufacture a wide range of portable compressors, but not a complete range. This also applies to Arpic. However, the new *combined* range of portables is one of the most comprehensive in the world. From one source you can now choose portable compressors with air deliveries ranging from 36 to 550 cubic feet per minute. From the smallest to the largest, and all sizes in between. Portables for any operation, any climate and any altitude.

INCREASED PRODUCTION FACILITIES WILL SPEED DELIVERY

Now that Atlas Copco and Arpic are one, their various plants will be at the disposal of a common direction and a combined team of production engineers. This dovetailing of facilities will mean increased production, as well as earlier, more reliable delivery dates for all types of compressors. It will also speed maintenance work and the supply of spare parts.

The compressors formerly sold under the Arpic name will henceforth be known as Atlas Copco Compressors, *Type Arpic*. They will continue to be manufactured and assembled at the plant in Antwerp, one of the biggest and most modern of its type in the world, and at an up-to-date plant in Glasgow.

POOLING OF TECHNICAL IDEAS WILL IMPROVE THE DESIGN OF COMPRESSORS

Both companies gain much by the pooling of technical information. You can expect, in the future, positive improvements in the design of all types of portable compressors. Atlas Copco and Arpic will now have access to the many outstanding technical features both companies have developed over the years. The new range of portable compressors will be more than comprehensive. It promises to be the most advanced and most reliable in the world.

AN EXTENDED WORLD-WIDE SERVICE

Arpic bring to Atlas Copco the services of something like 30 overseas depots. There will now be a total of 80 Atlas Copco companies or agents selling and servicing the new range of compressors all over the world. This reorientation greatly extends the on-the-spot service available to users.

The Atlas Copco Group of Companies

Compressed Air Engineers ★ Now incorporating the* ARPIC *Companies

For further details about the new range of compressors and the increased servicing facilities, write to your local Atlas Copco company or agent or to Atlas Copco AB, Stockholm 1, Sweden

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Teddington Industrial Equipment Limited manufacture thousands of thermostats of all types and have over 25 years knowledge about their application. Our experience is freely available.
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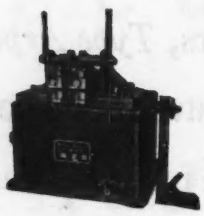

5 kVA Bench Butt Welding Machine

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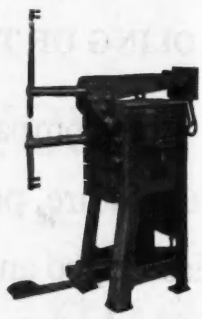

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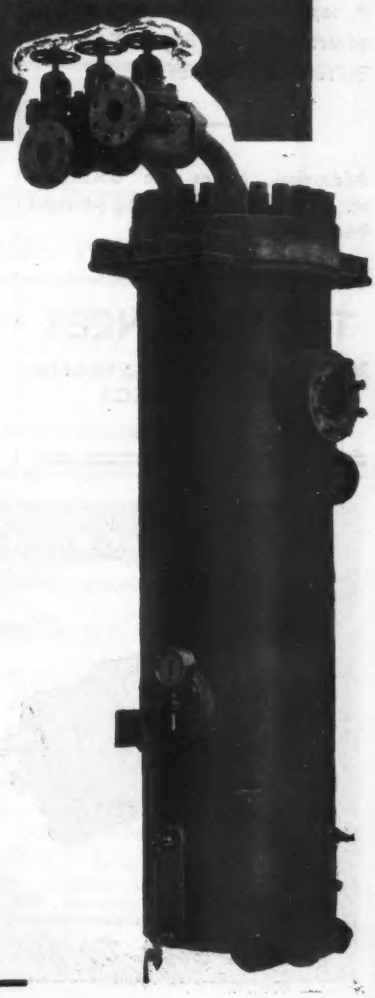

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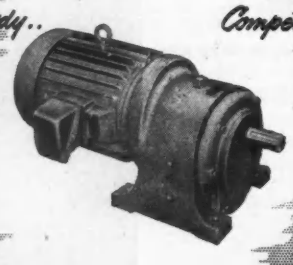

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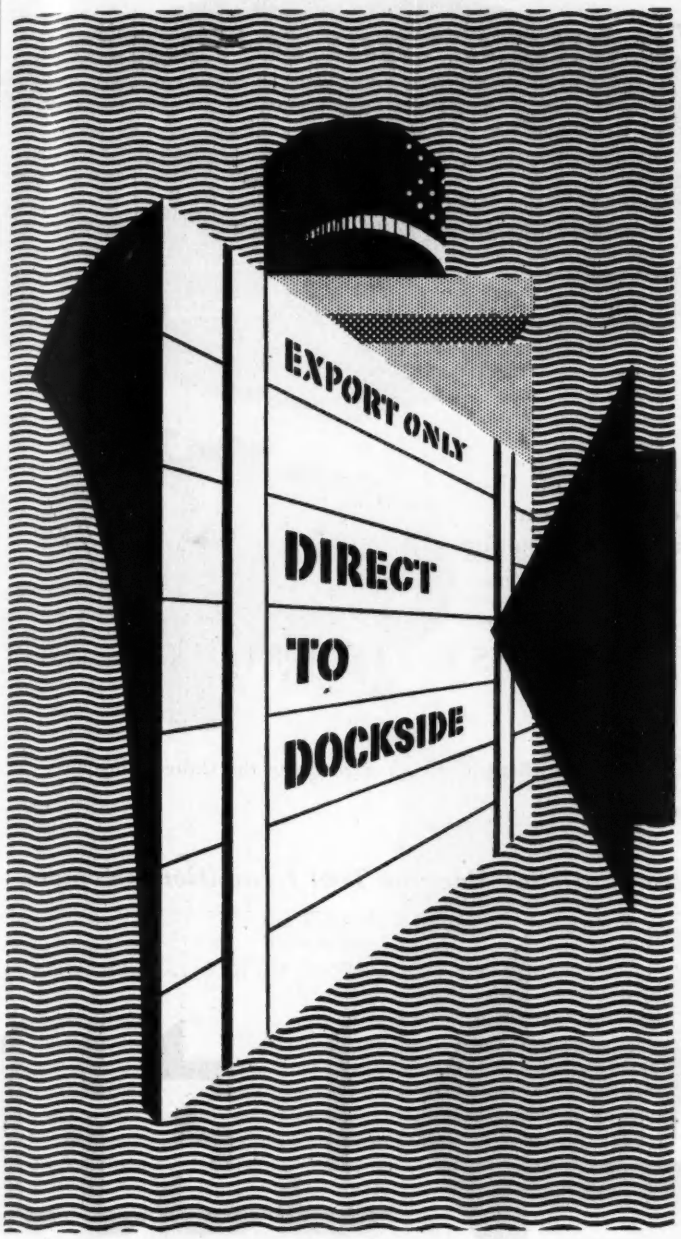

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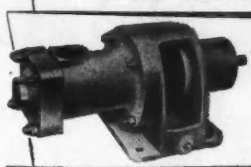

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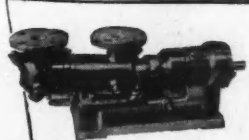

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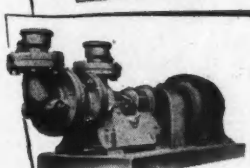

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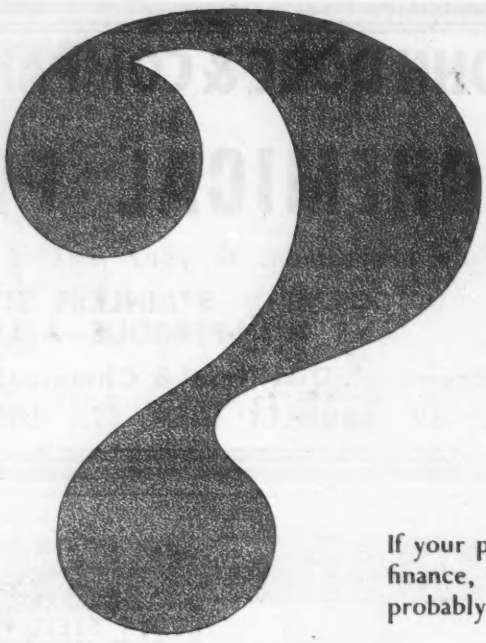

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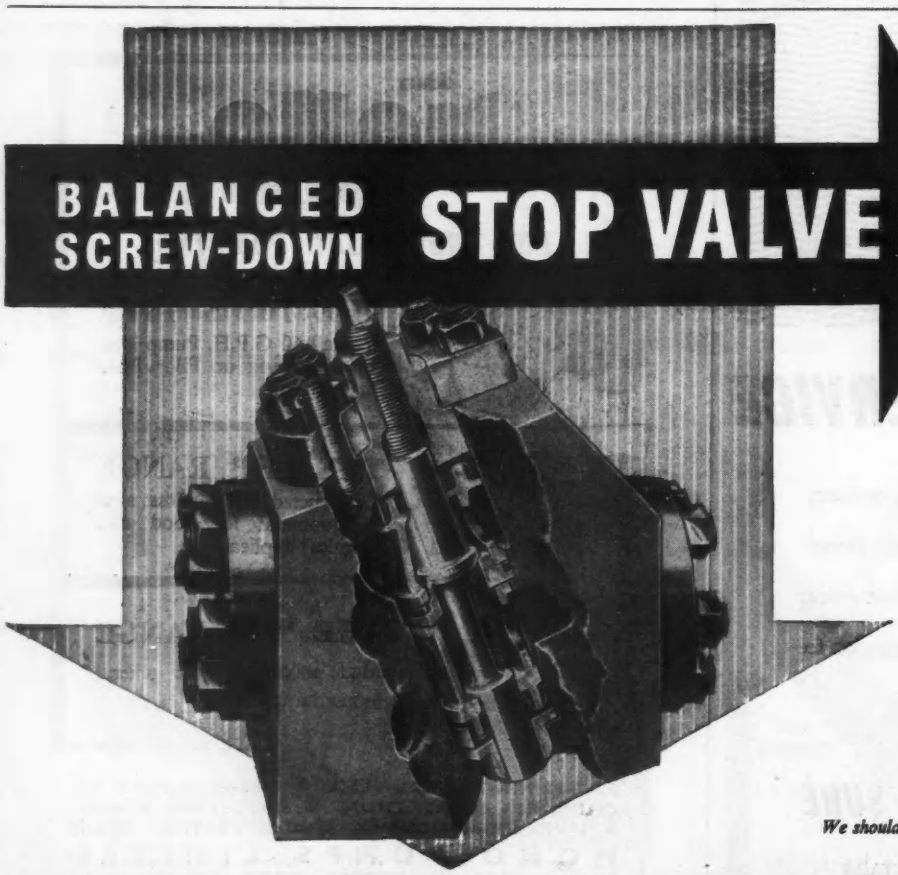

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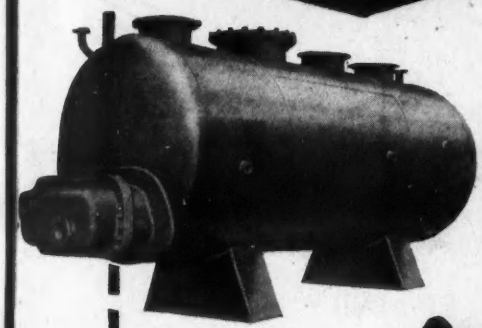

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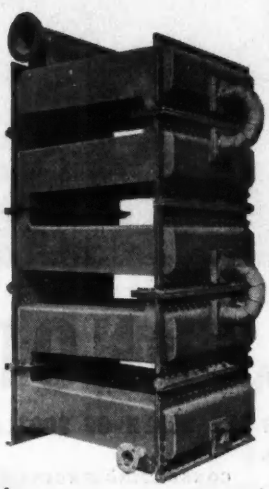

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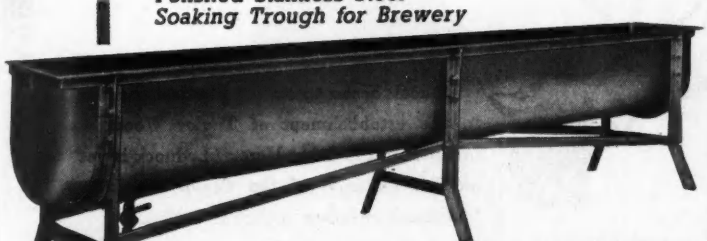

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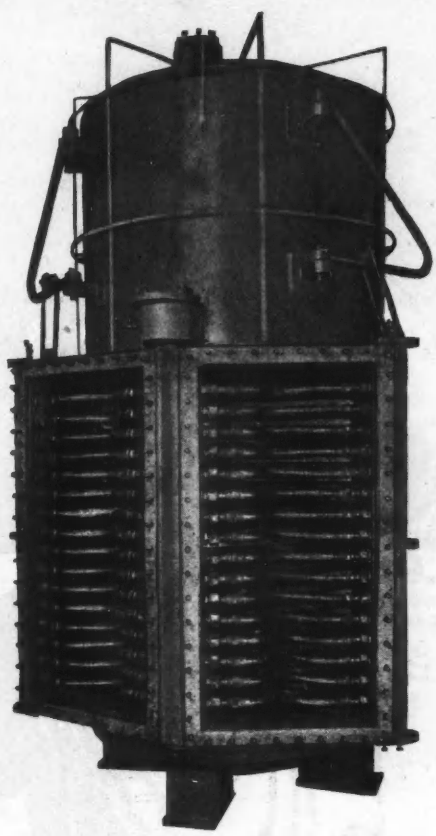

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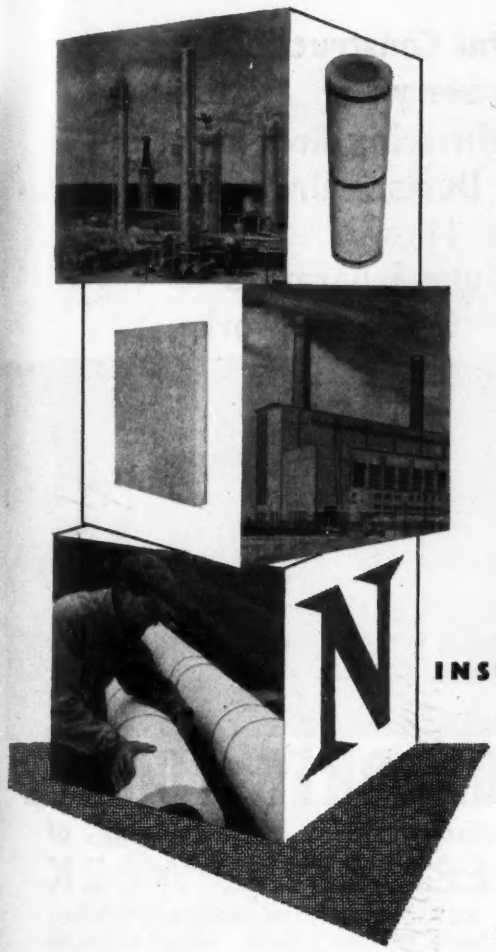

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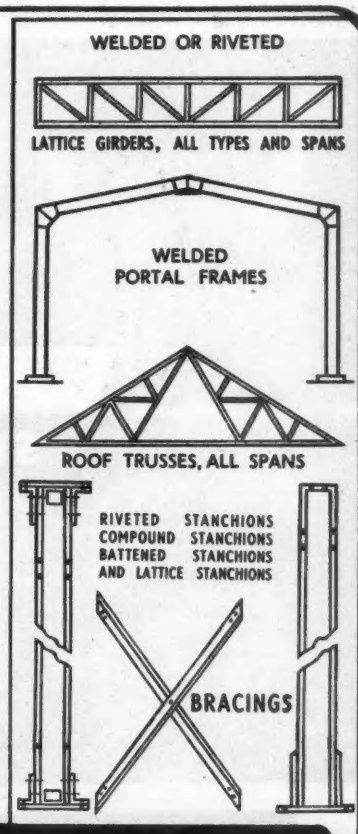

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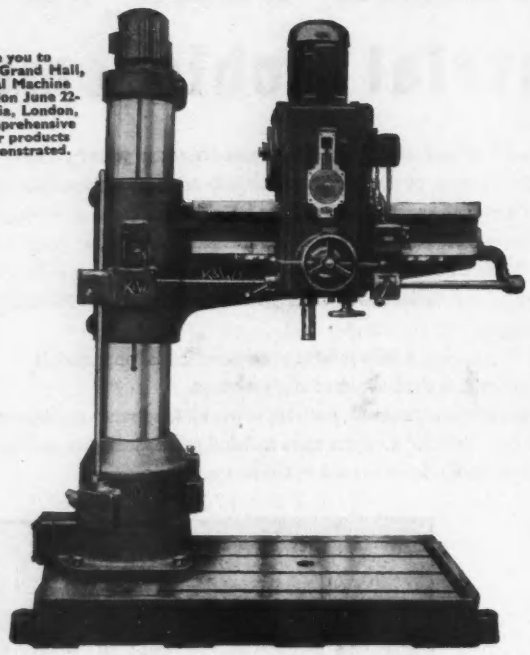

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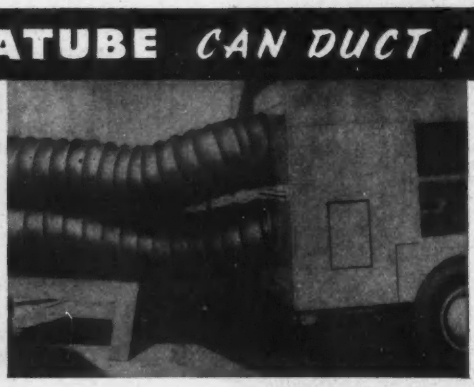

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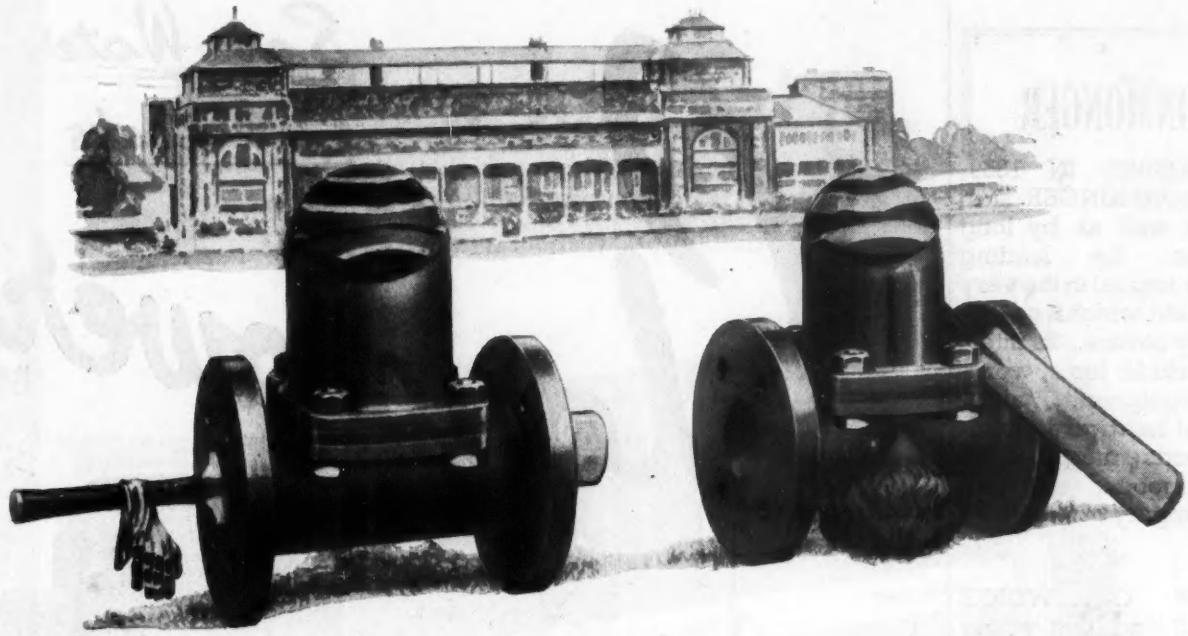

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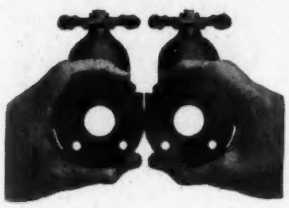

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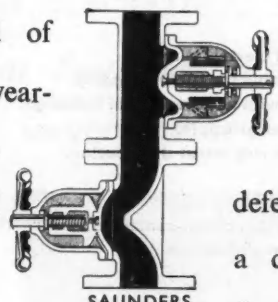

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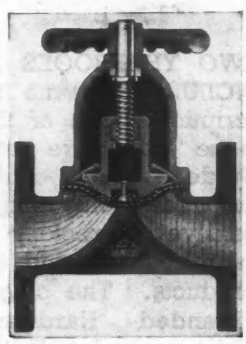

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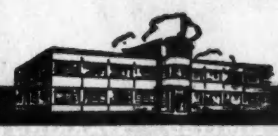

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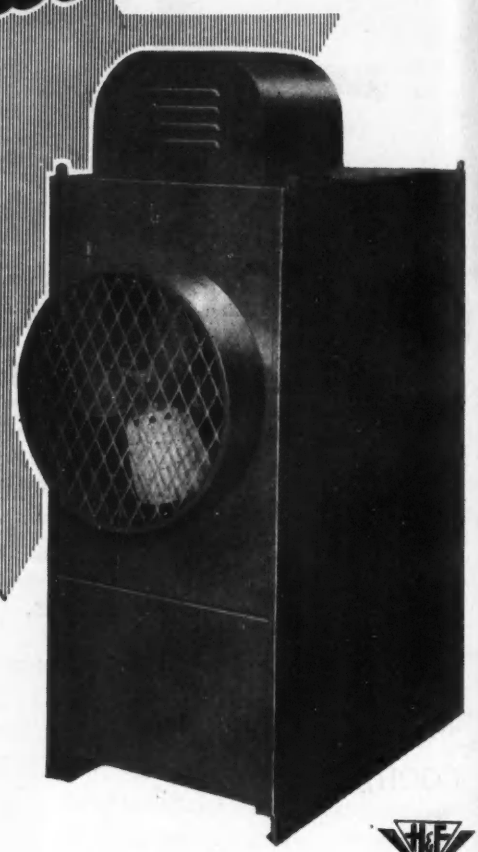

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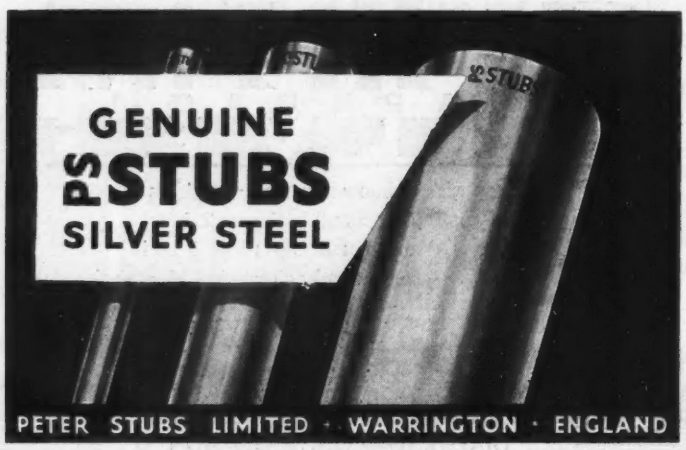

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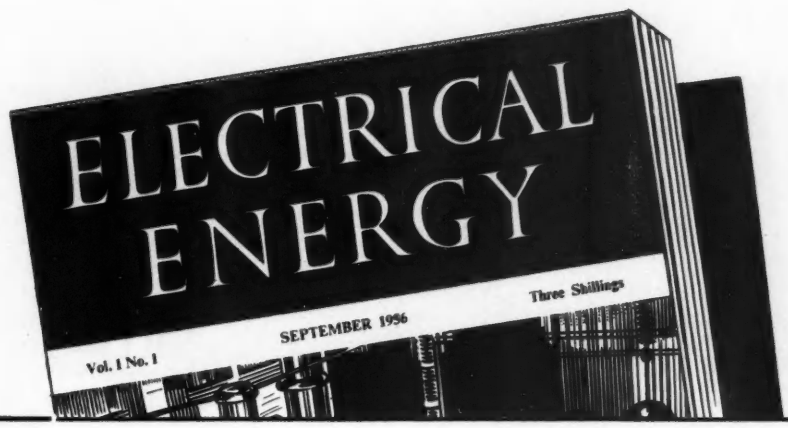

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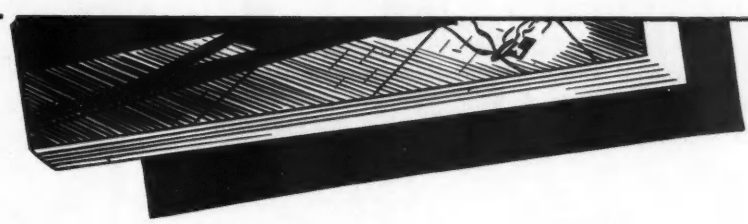

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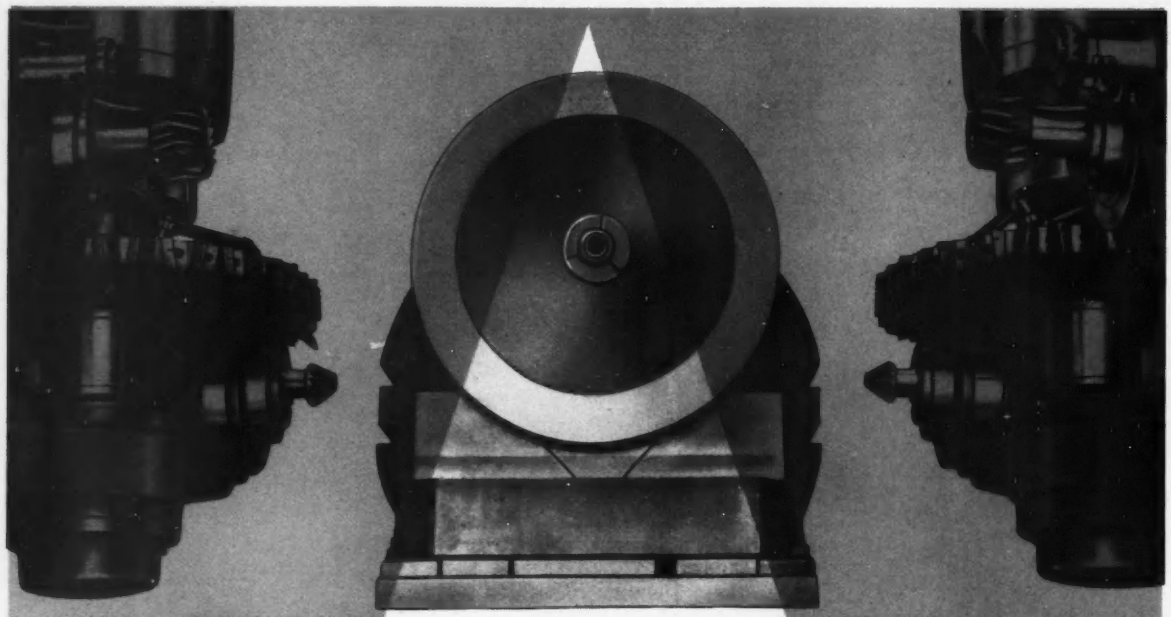

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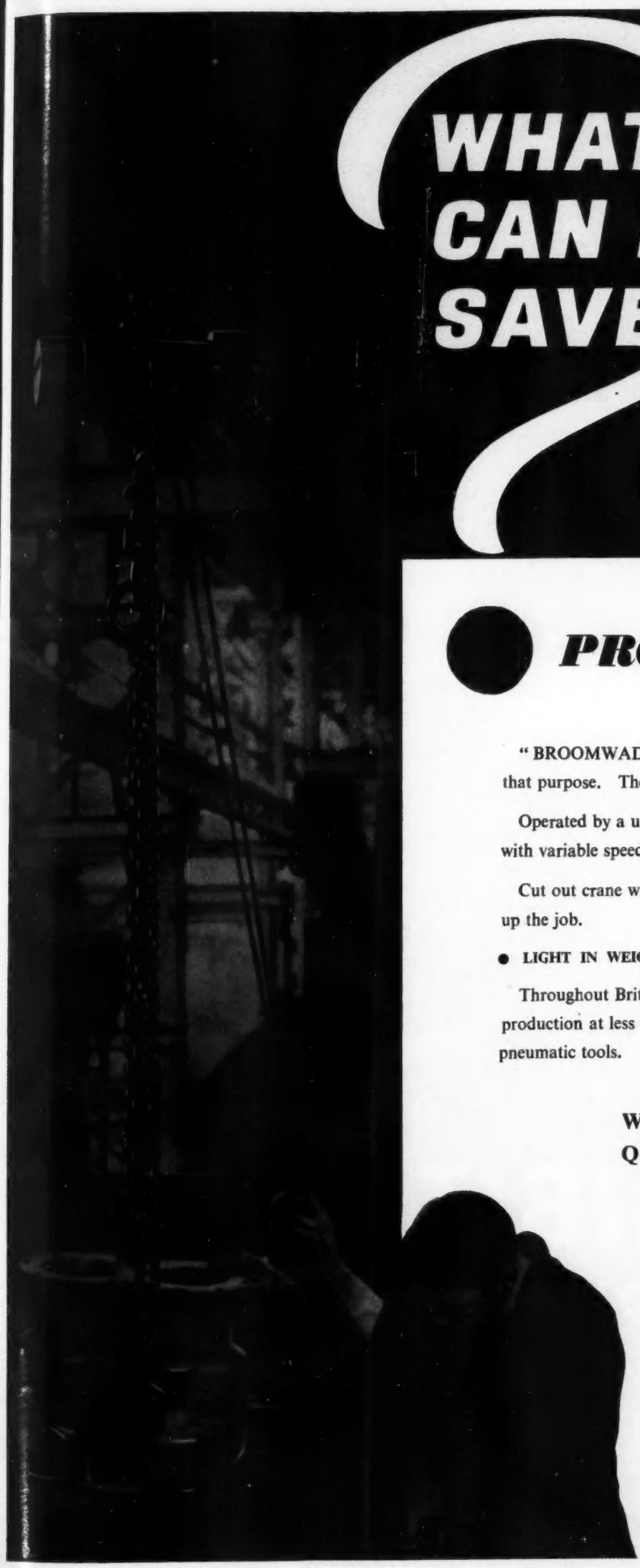

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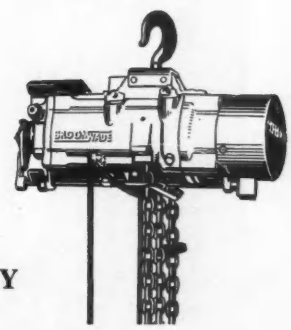

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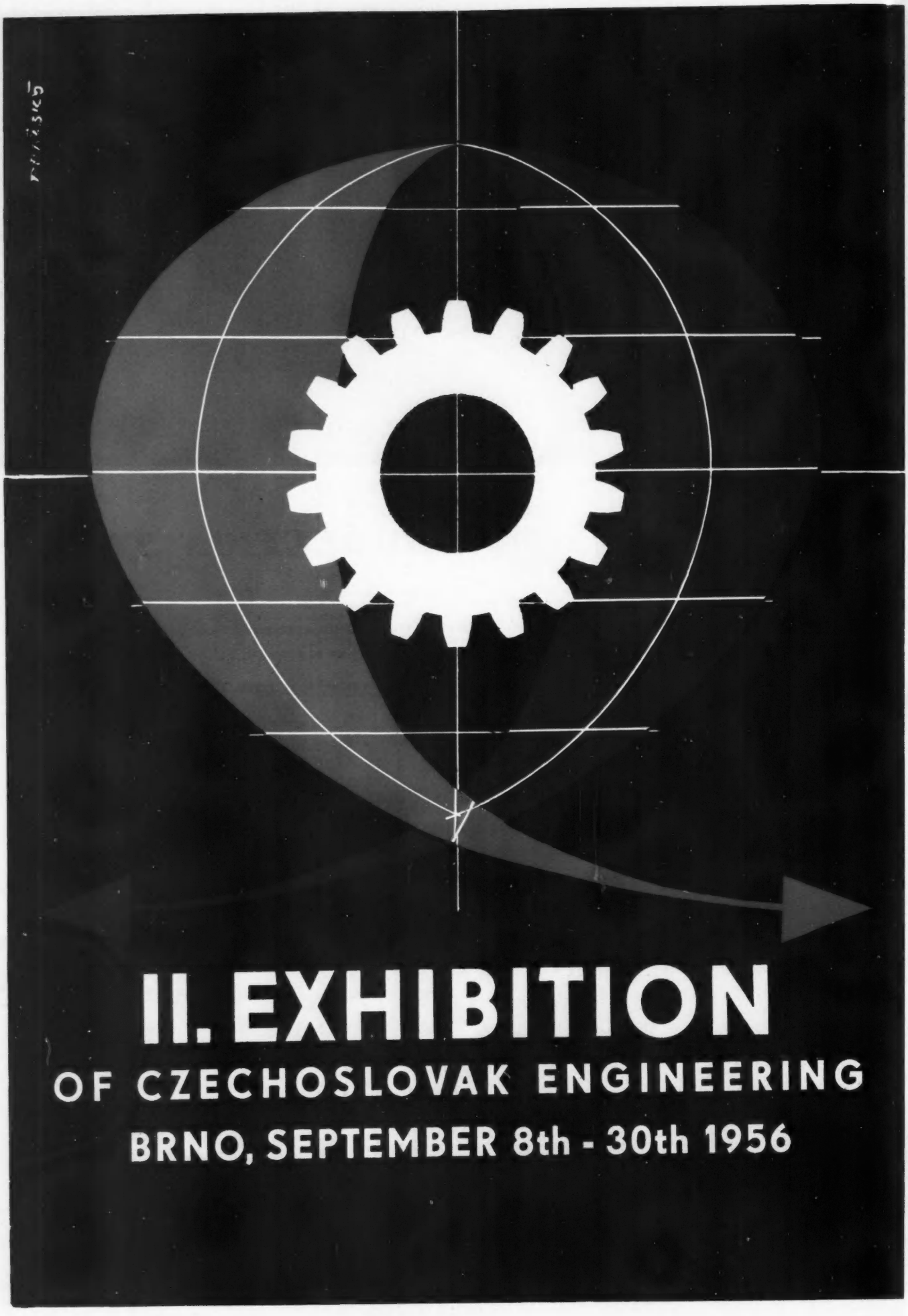
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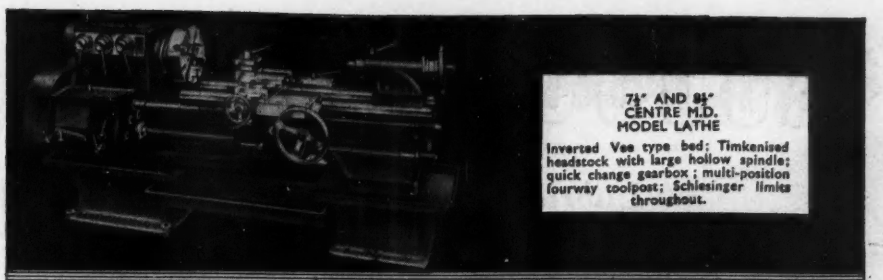

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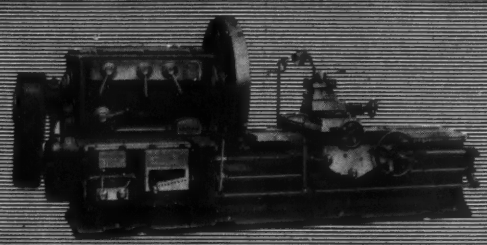

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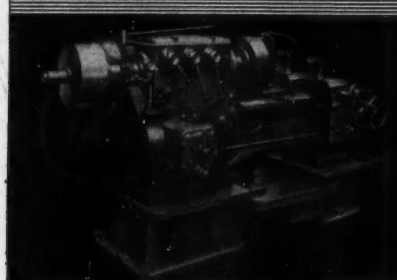

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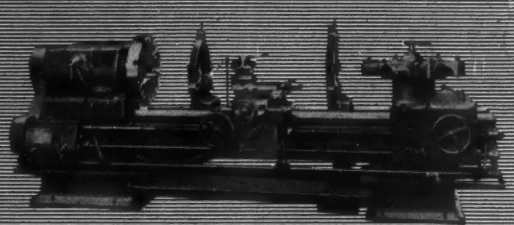

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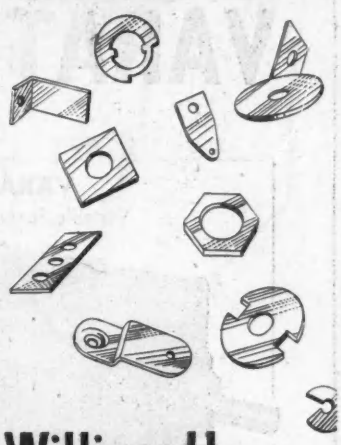

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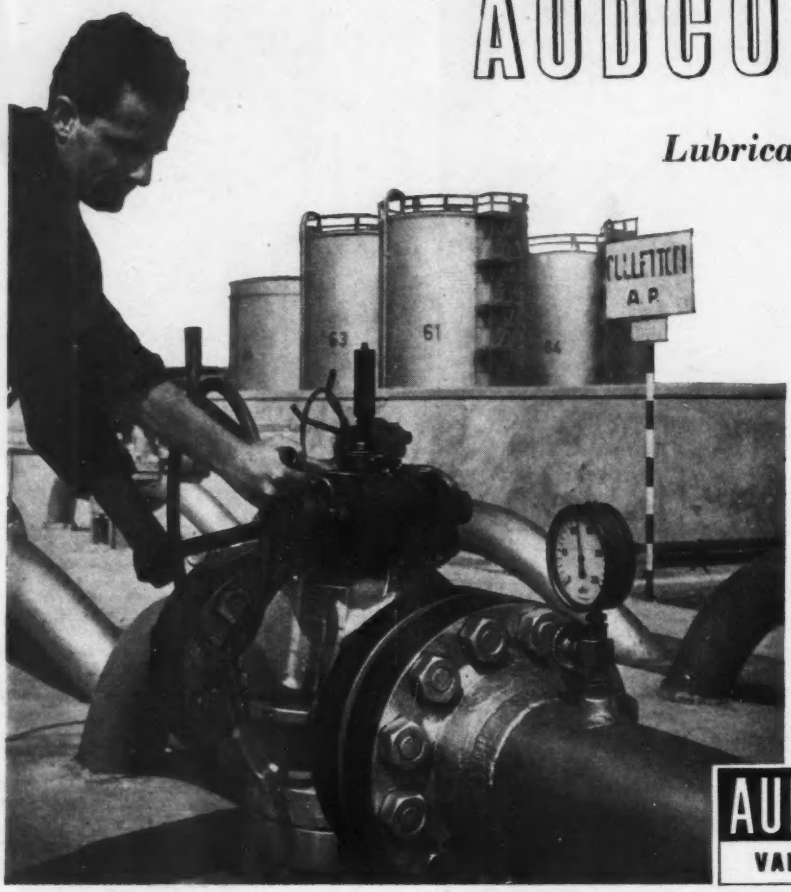

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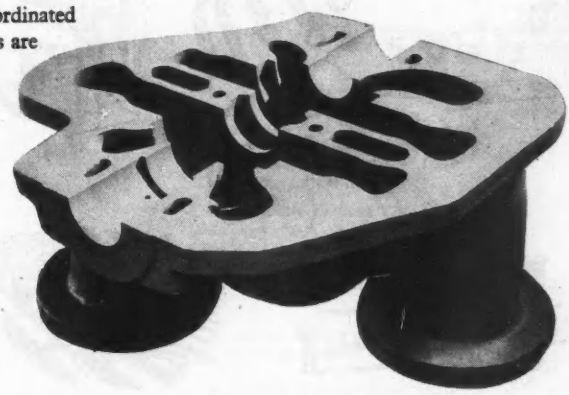

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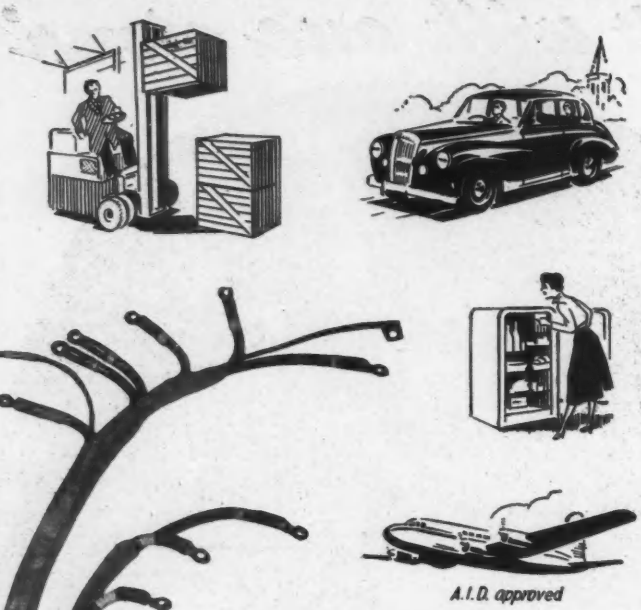

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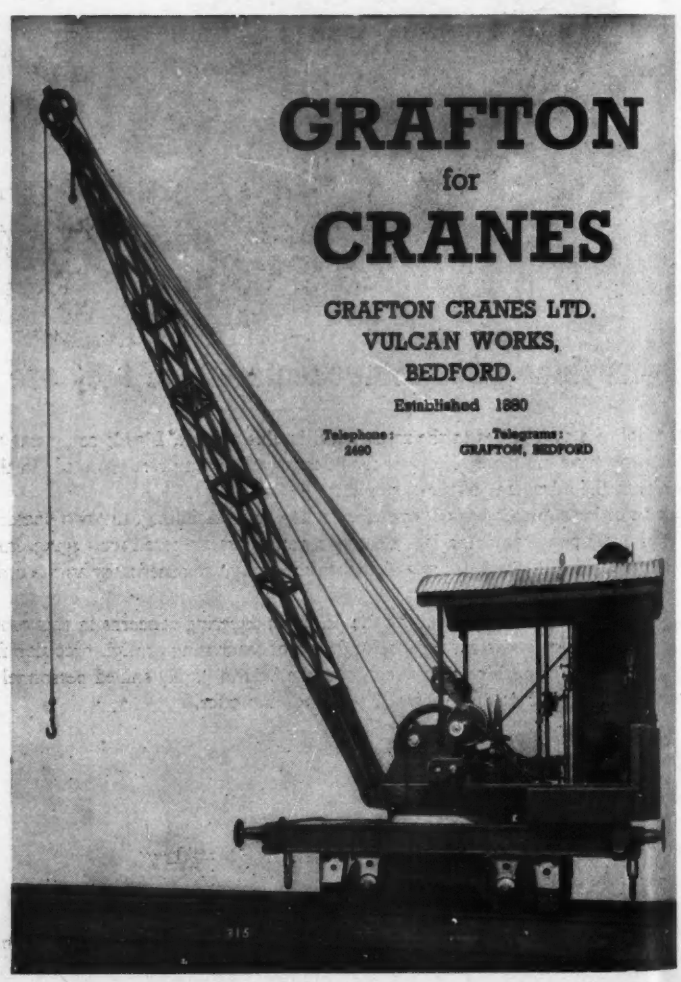

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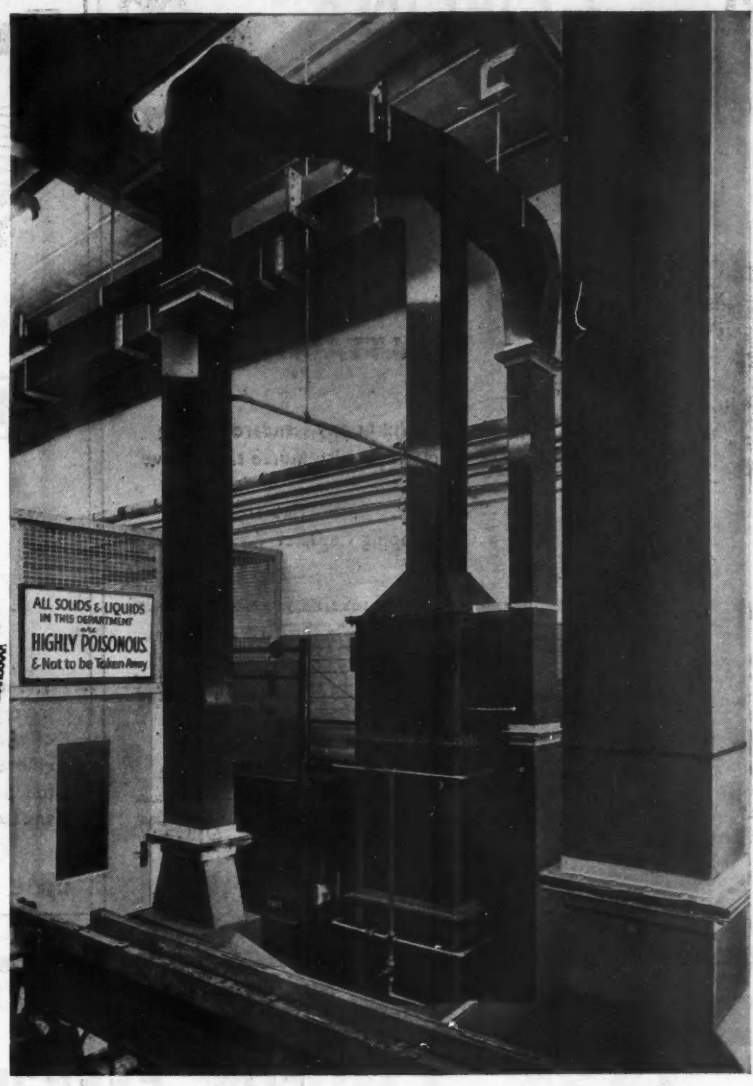

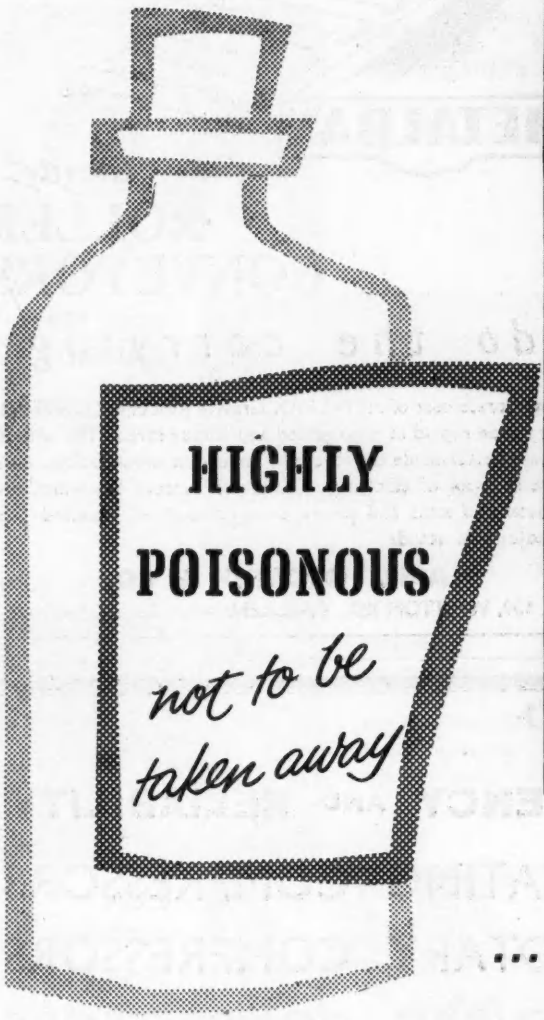

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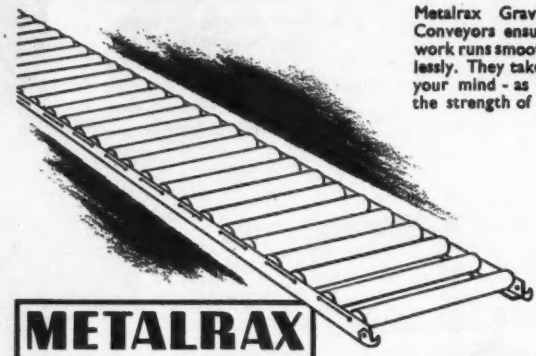

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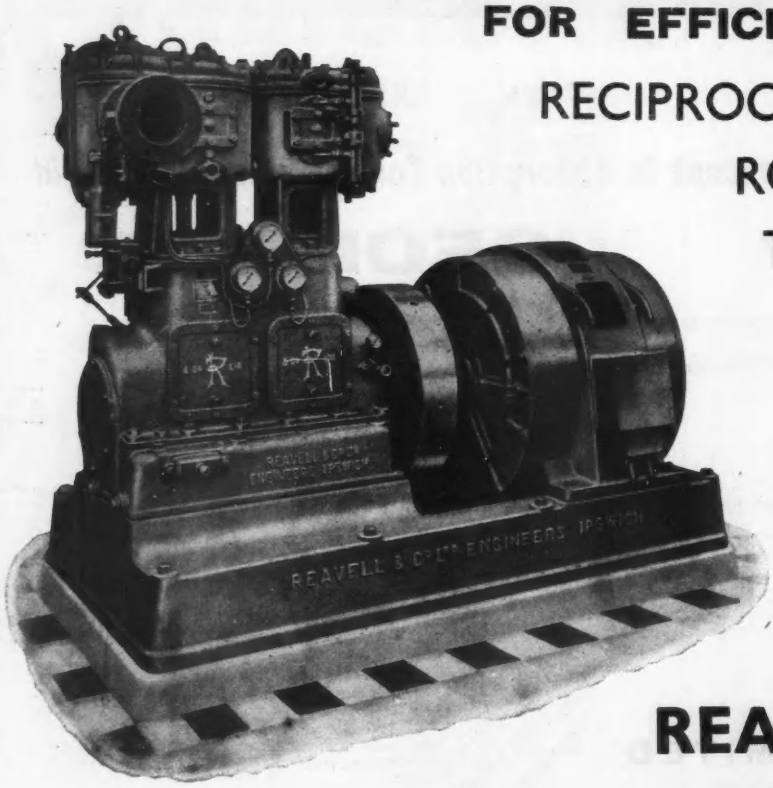

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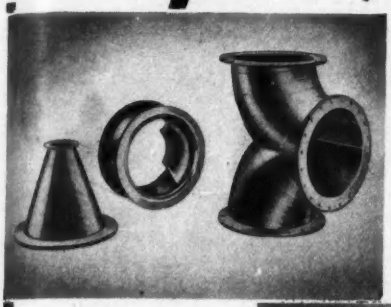

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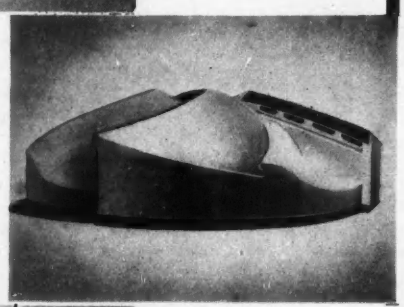

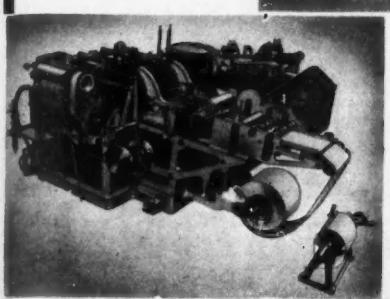

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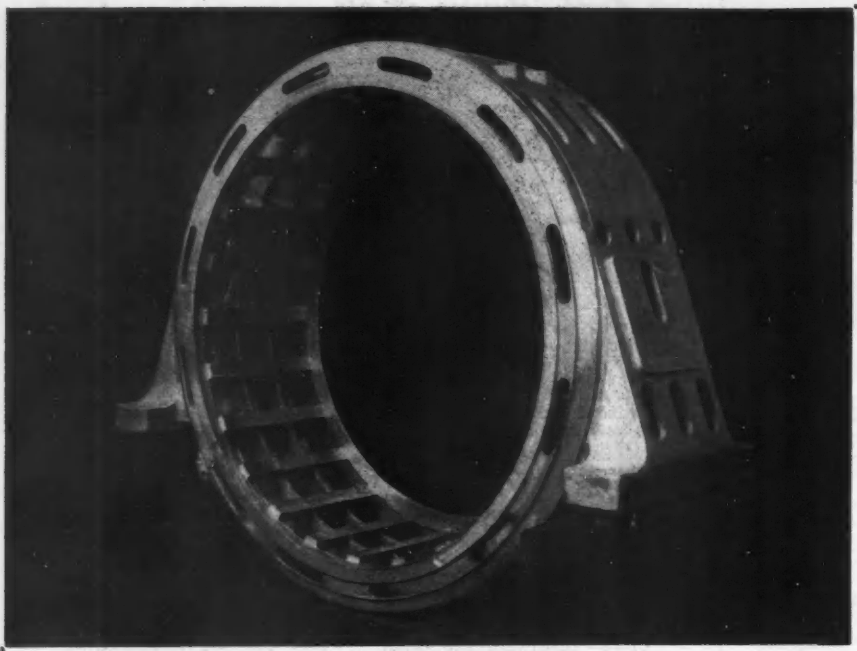

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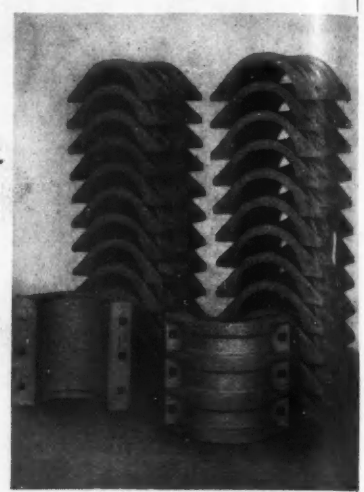

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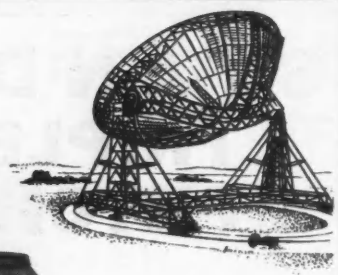

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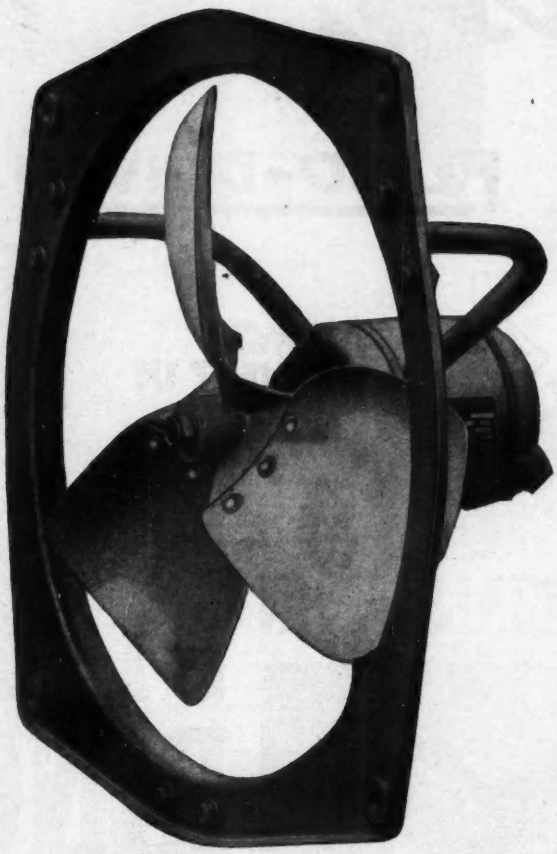

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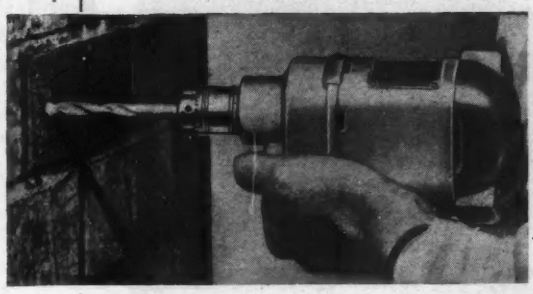

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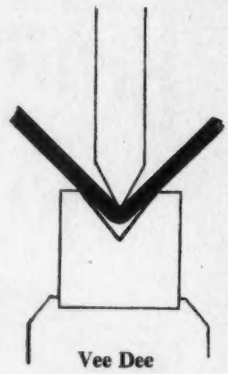
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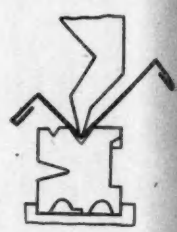

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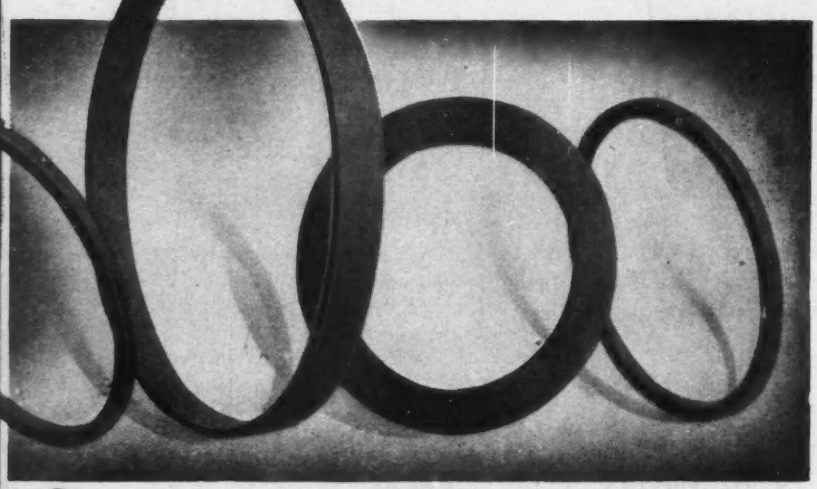

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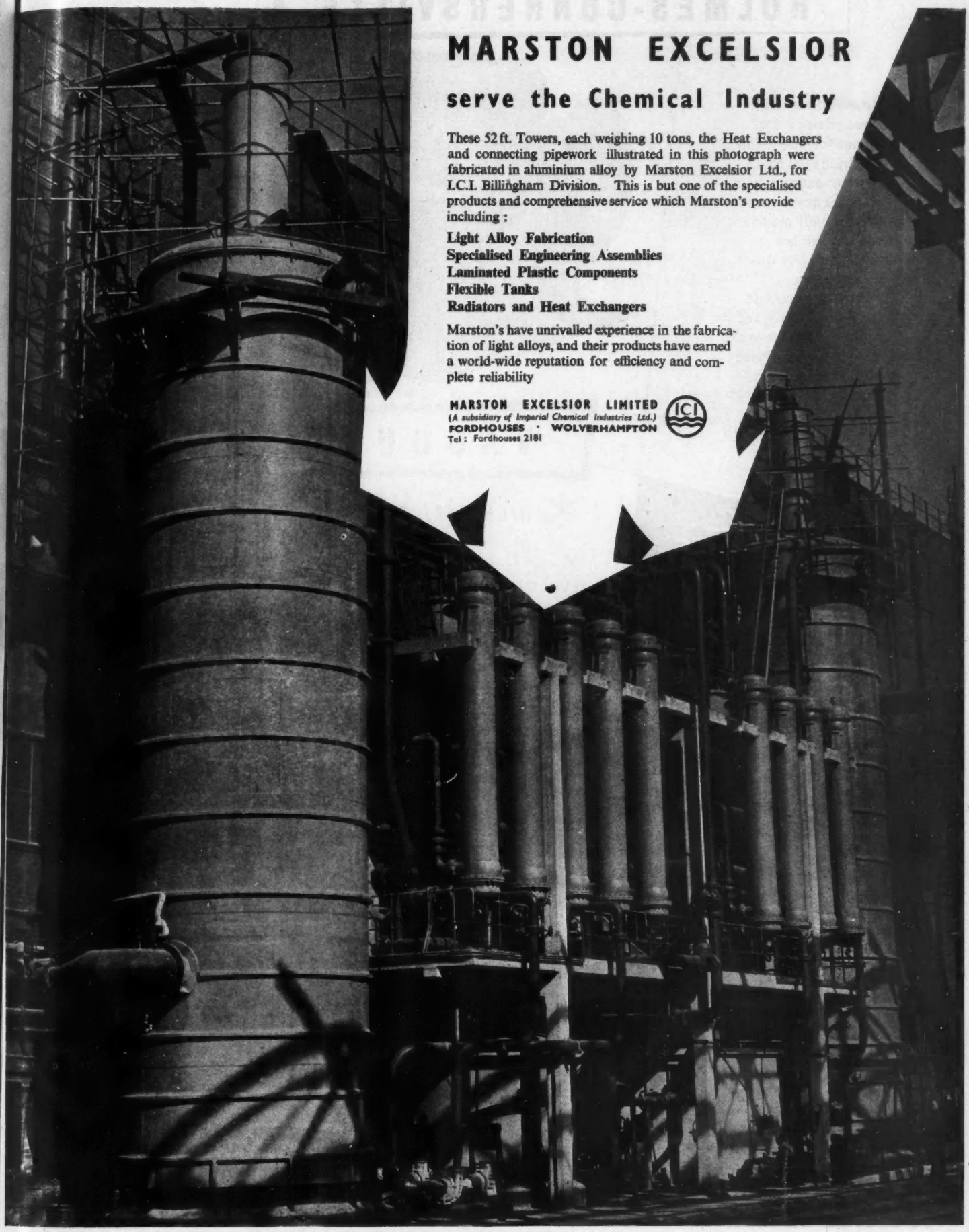

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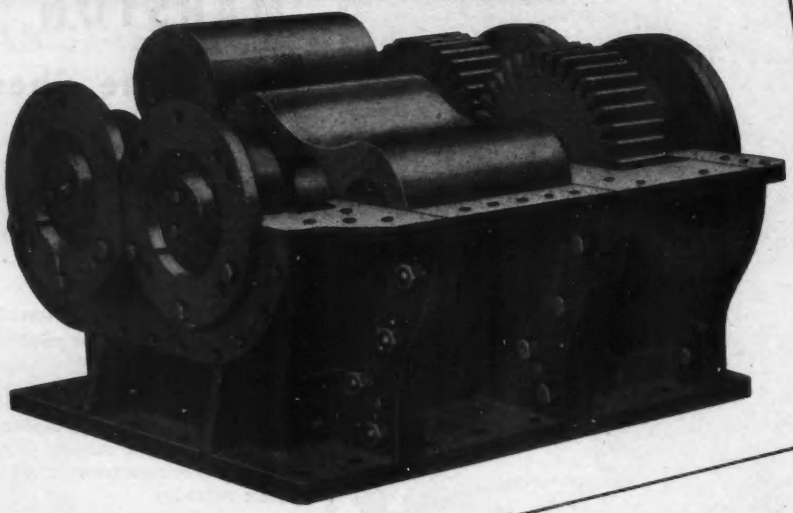

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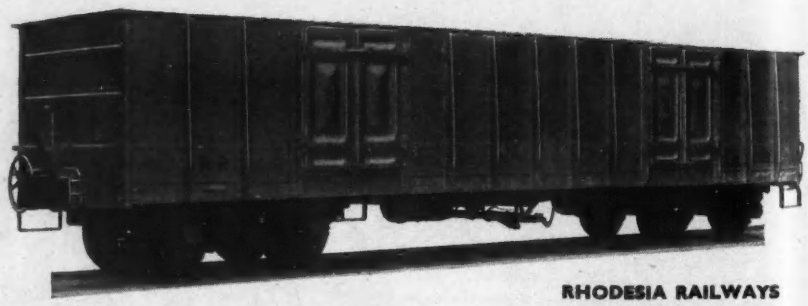

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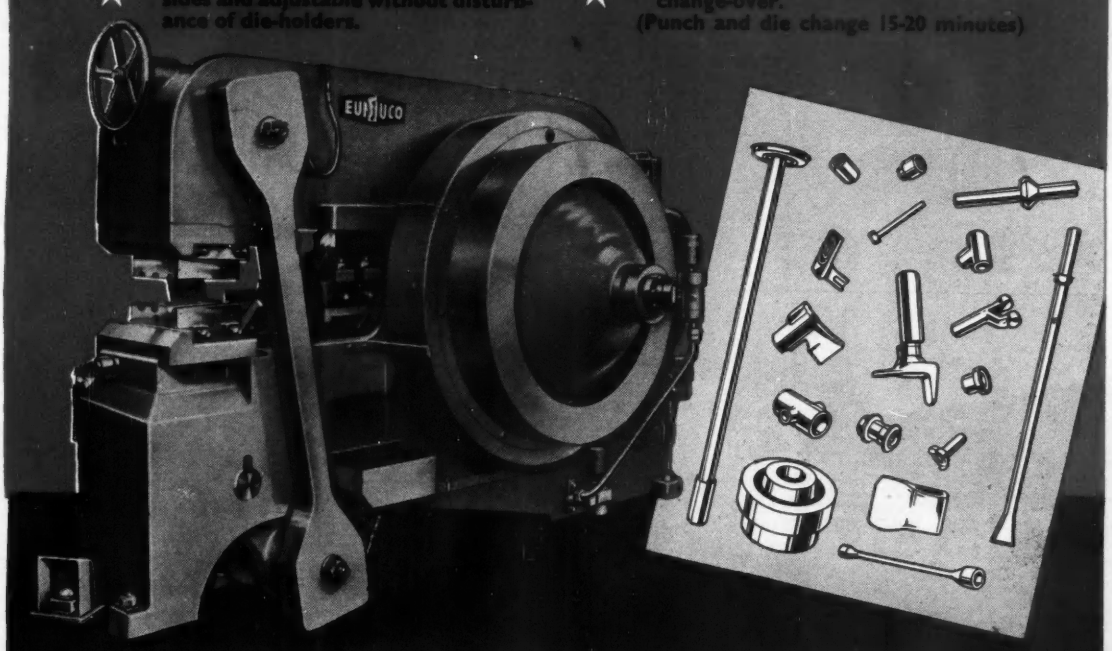

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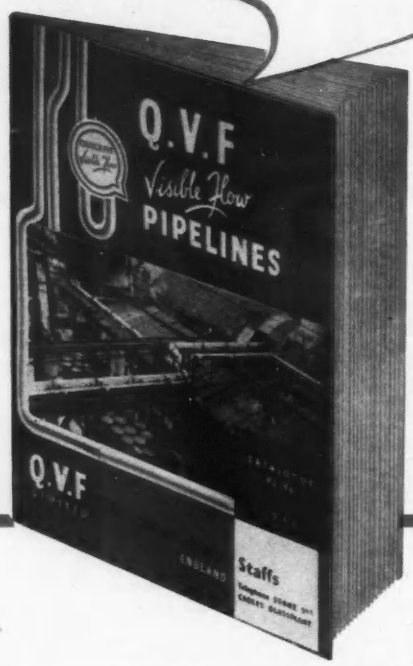

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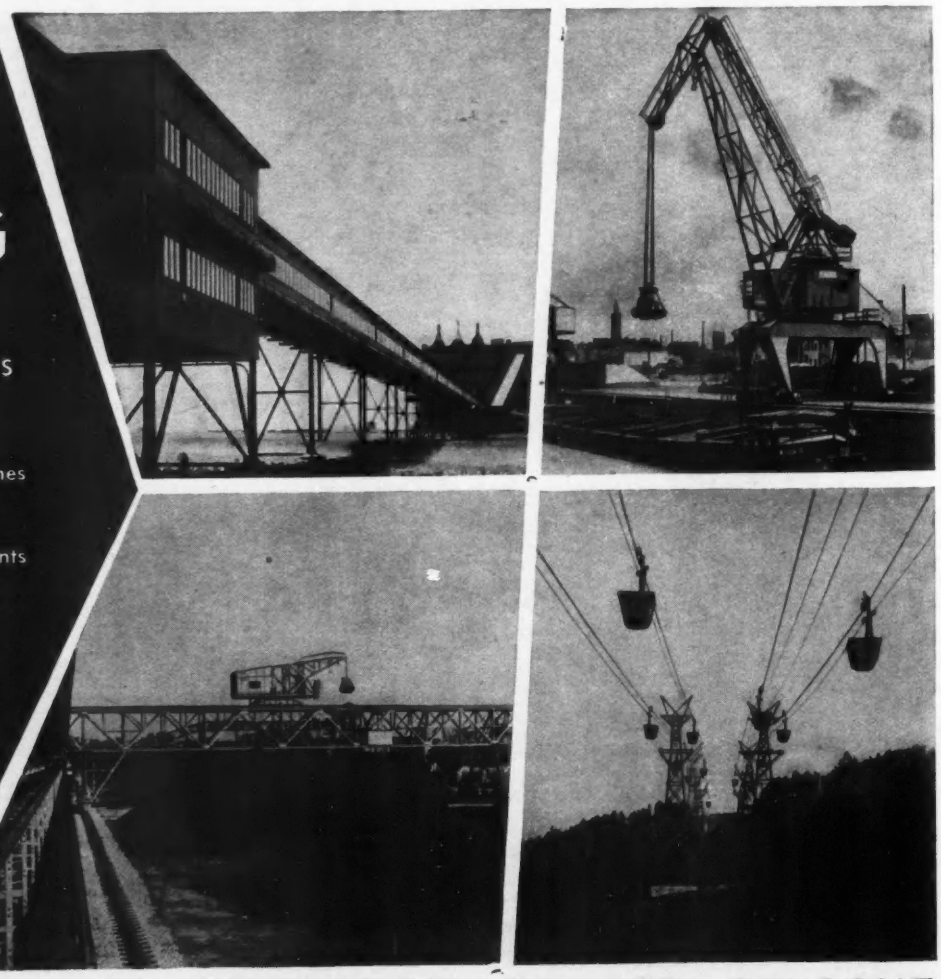

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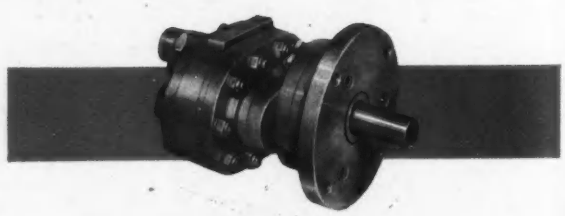

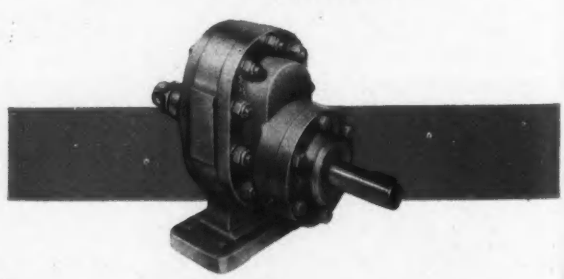

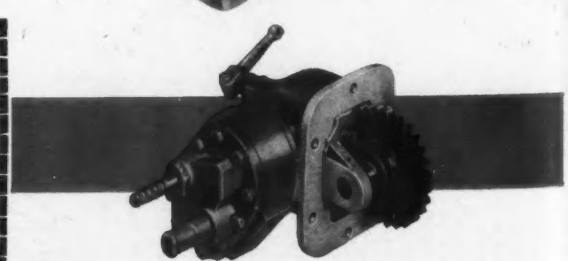

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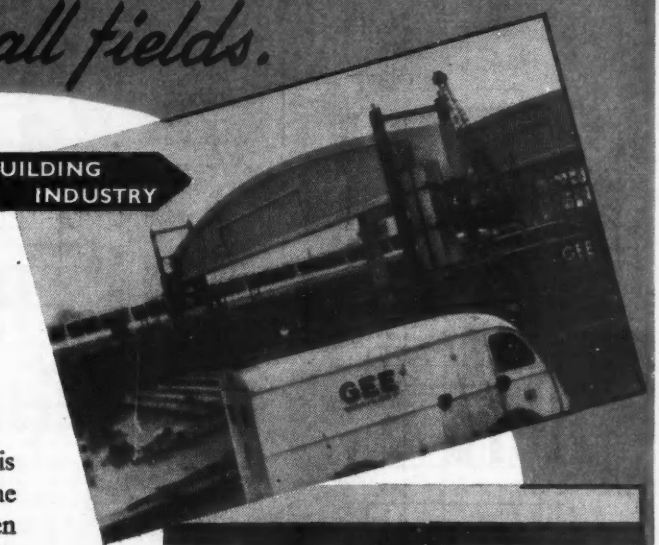

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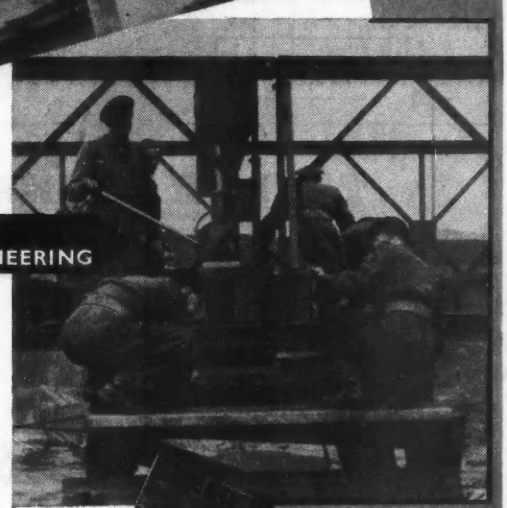

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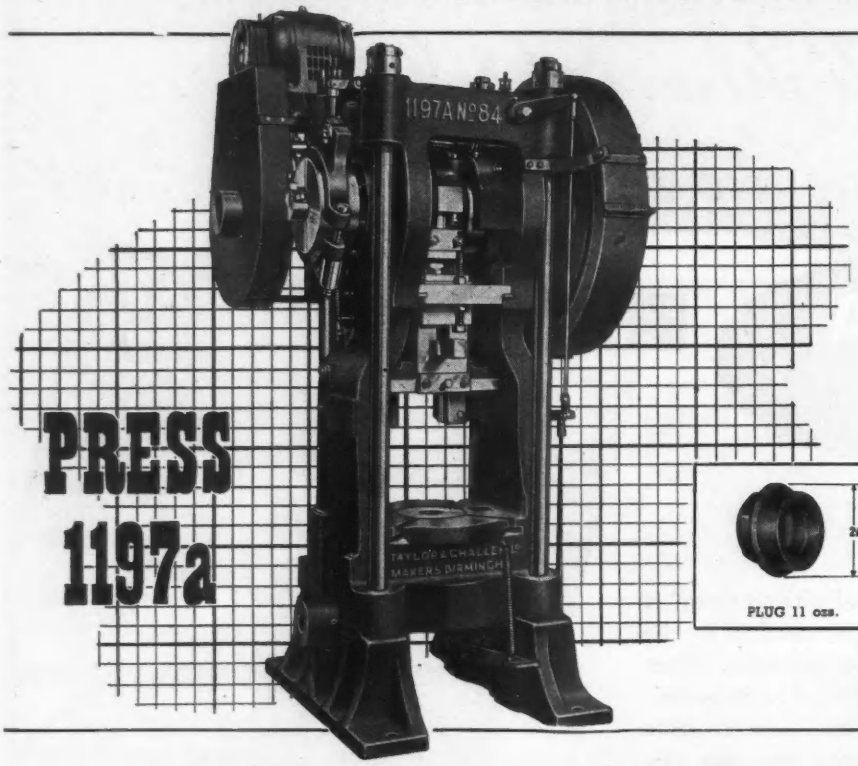

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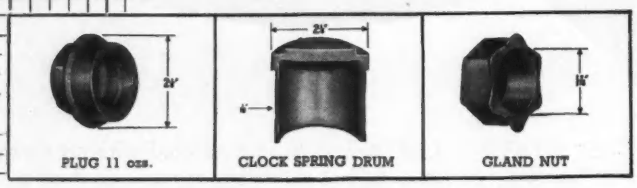

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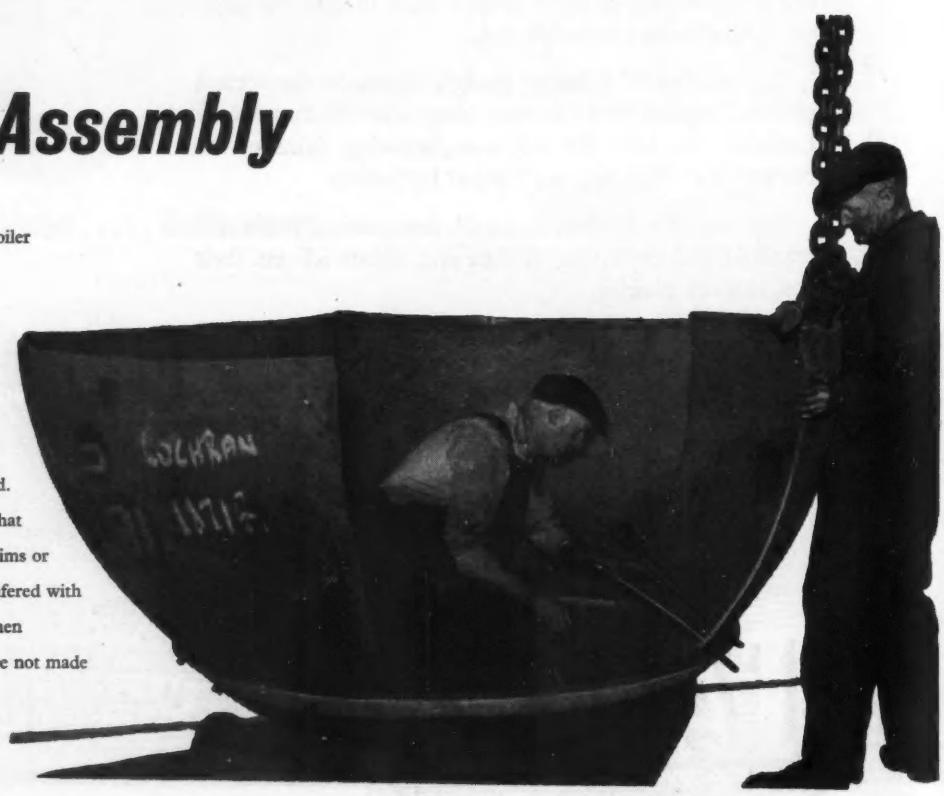

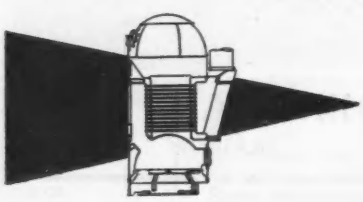

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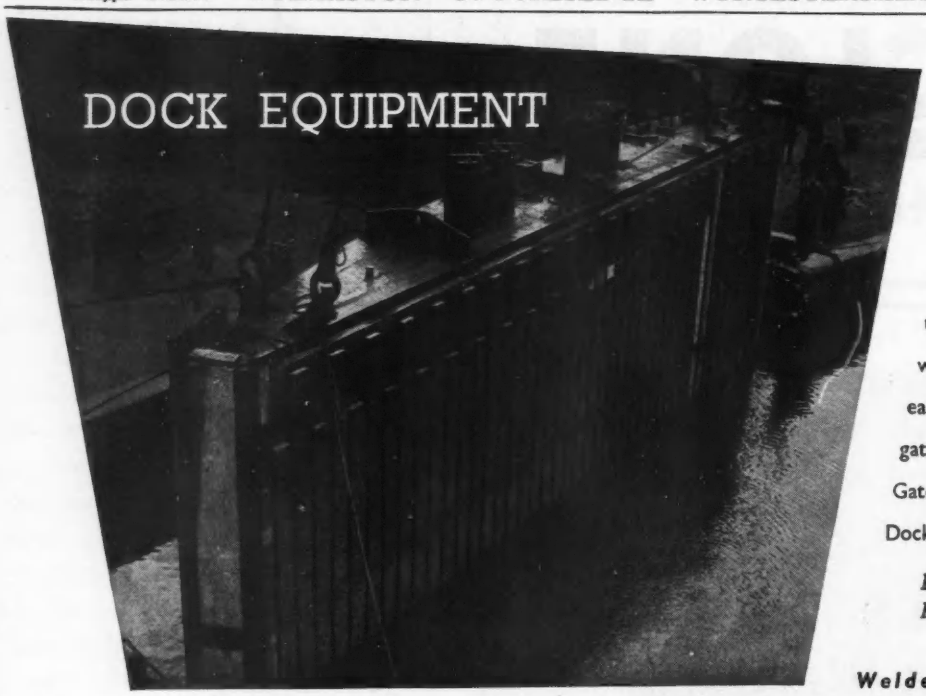

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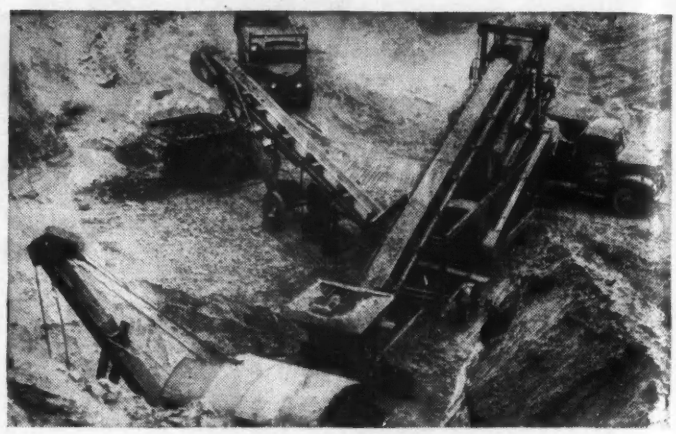

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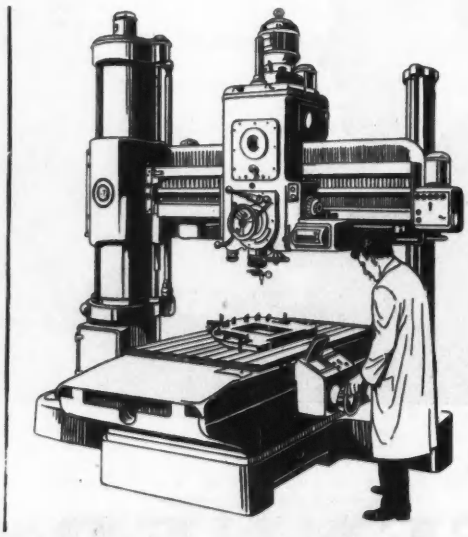

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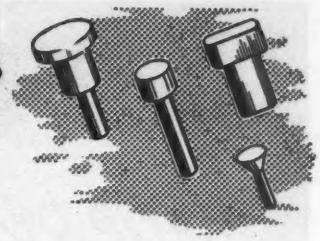

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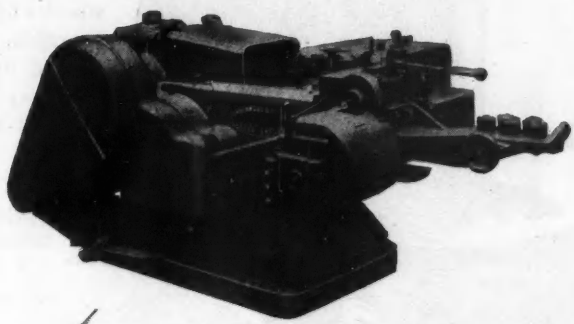

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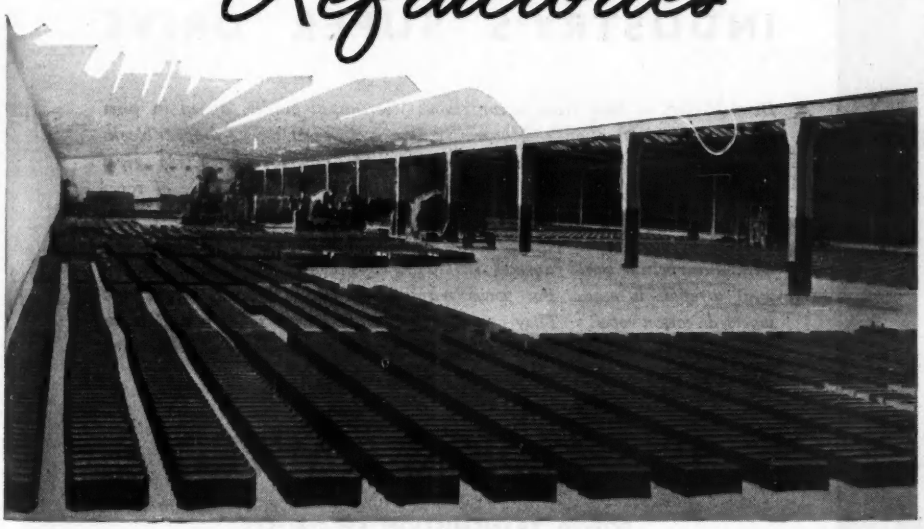

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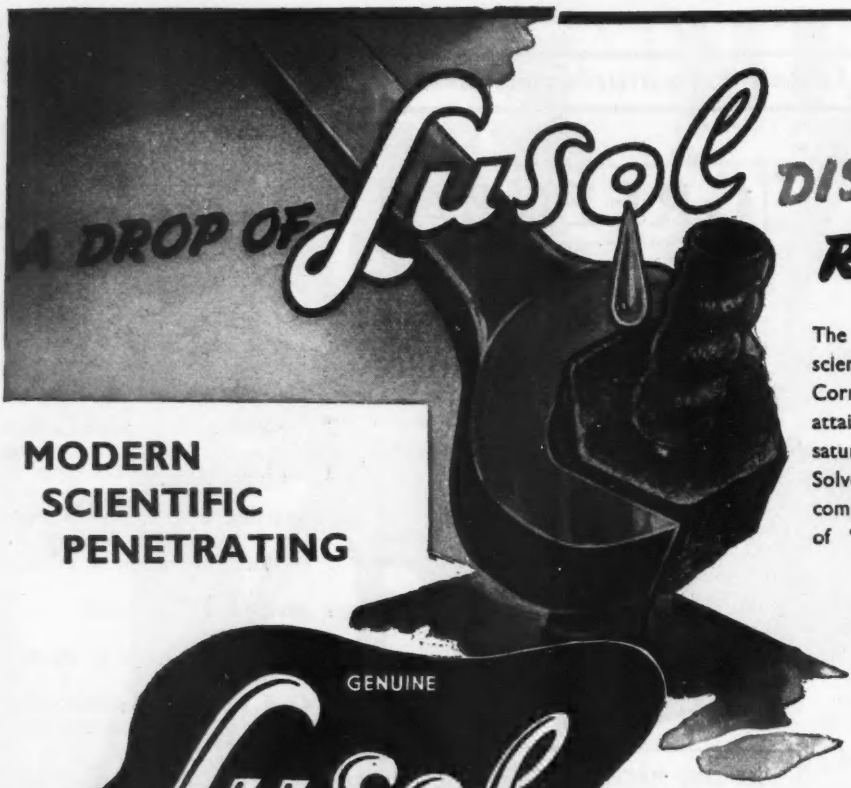

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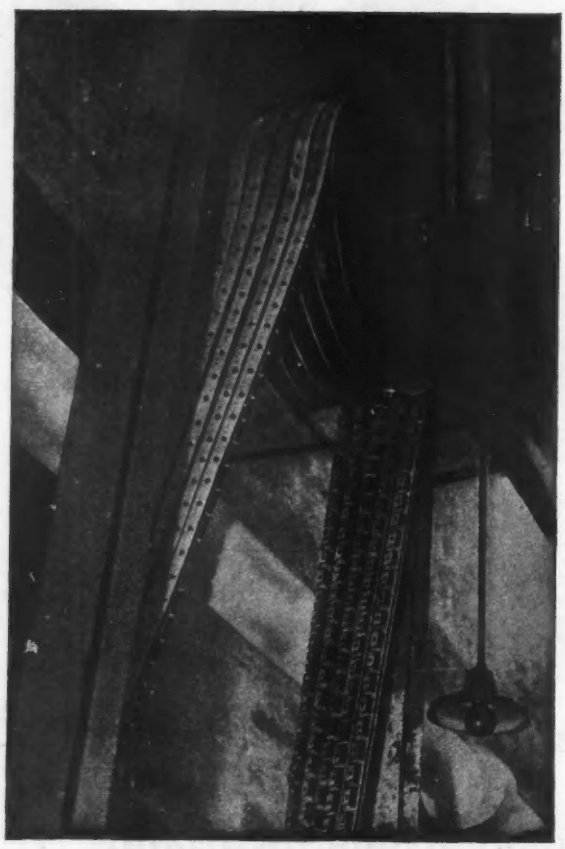

Quarter twist Dixel drive, 78 h.p. 122 r.p.m. 5 - 1¼" ropes.

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Dixel V-Rope is built from a continuous Vee-shaped binder lapped in plies to which is rivetted on the narrower face a series of wedge-shaped blocks tapered both laterally and longitudinally. This unique construction gives Dixel V-Ropes an enormous strength which minimises the number of ropes required on a drive. They are designed for heavy drives up to 3,000 h.p., and are manufactured from the same high grade materials that have made Dickbalata belting world famous. Should one rope break the remainder function until a repair is made. For power transmission Dixel V-Ropes exceed and supersede cotton ropes. They can be spliced endless with solution and rivets or with our "Quickfix" bolts. Dixel V-Ropes are also supplied in sizes to replace 40° angle rubber Vee ropes.

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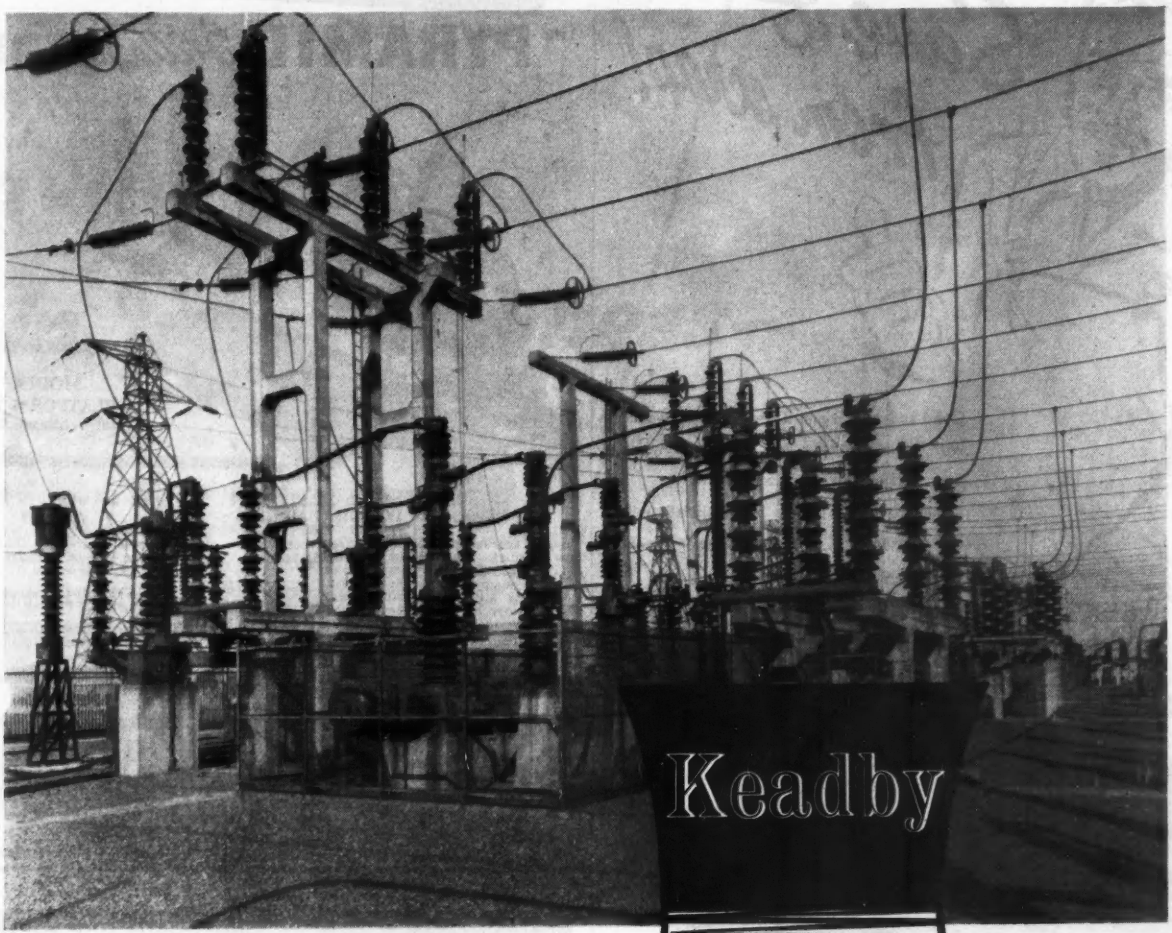

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Keadby power station

Consulting Engineers: Ewbank & Partners

The 132-kV generator and transmission circuits of Keadby Power-Station are controlled by Reyrolle 2,500-MVA air-blast circuit-breakers.

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with hydraulic -lift platform

MODEL 107
PLATFORM 26" wide for stillage handling.

STEEL PLATFORM: 59½" long × 26" wide. ELEVATION: 6"
LOADING HEIGHT: 10½". LOAD: Up to 1750 lb

Designed specifically to cut the cost, and speed the flow of stillage handling, the PYRAMID Stillage Truck is fitted with a foot operated hydraulic pump to elevate the platform. Riser links are self-lubricating—need no maintenance. The entire assembly is rigidly constructed for lasting service.

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PYRAMID ECONOMY! A WEEK'S WORK FOR ONLY 10/- Petrol consumption is normally only ¼ pint per hour . . . half-a-gallon a working day.

REVERSIBLE—simply rotate drive unit through 180°.

EASILY MANŒUVRABLE—in confined spaces. Turning circle of only six feet.

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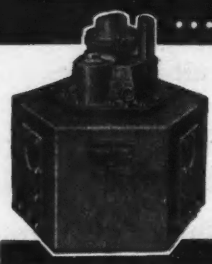

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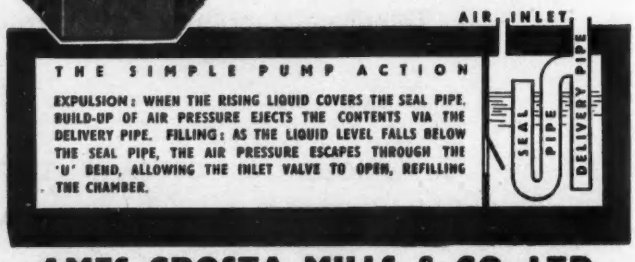

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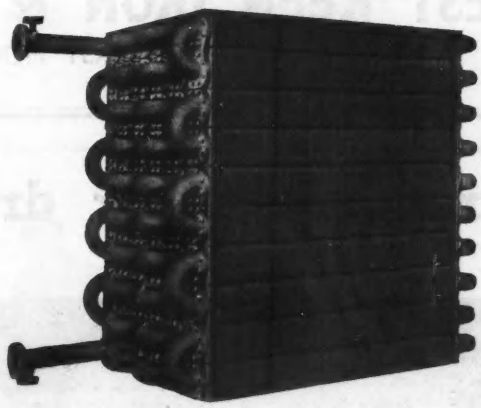

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This illustration is reproduced by courtesy of Messrs. The Power-Gas Corporation Ltd., Stockton-on-Tees, and it portrays one of their large drawing offices equipped with Mason drafting reference units.

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installed for boring and facing the crankcases of high-quality Diesel Engines

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Three worktables have been set up at right angles to the machine bed and workpieces are positioned on two tables whilst the machine is operating at the third. Machine idle time is therefore kept to a minimum, and since the Asquith H.R.G. is of modern design planned for operating convenience, a high output is assured.

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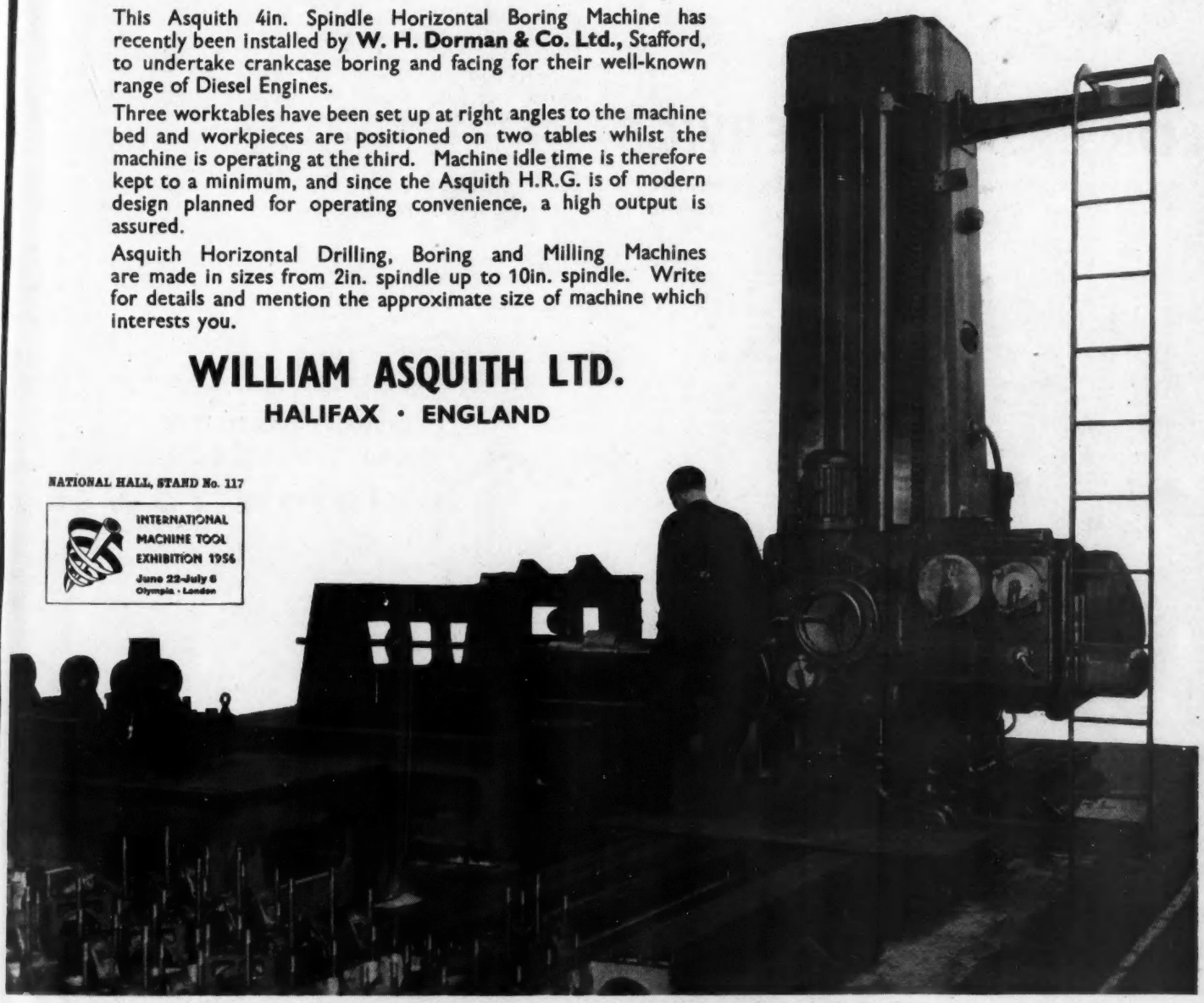

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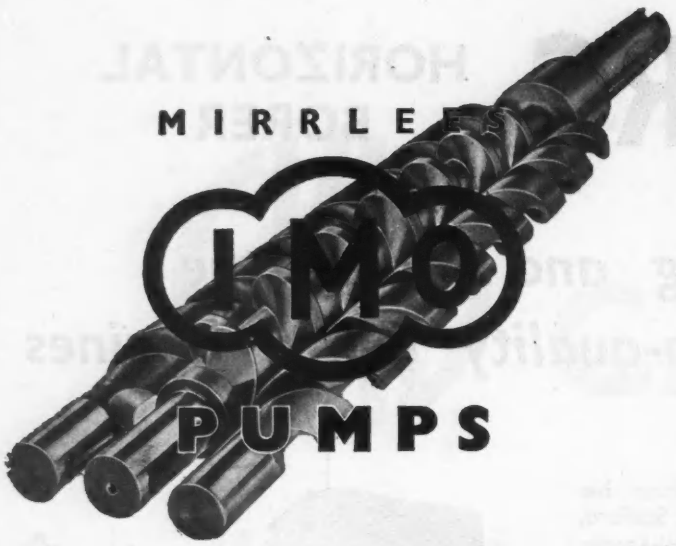

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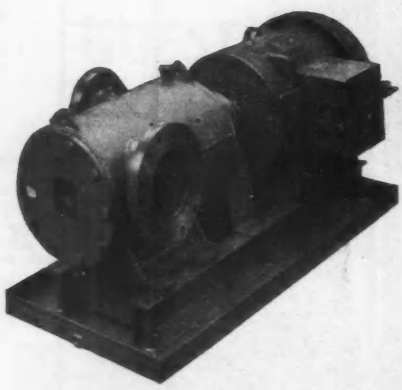
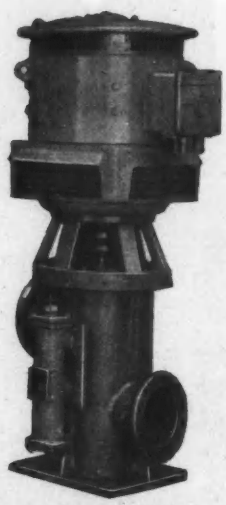


Horizontal unit for oil transfer. Outputs from 100 to 1,300 g.p.m. at discharge pressure up to 150 lbs per sq. inch.

Oil tank mounted units. Outputs 100 to 1,300 g.p.m. Discharge pressures up to 300 lbs per sq. inch. Note absence of suction pipe-work.



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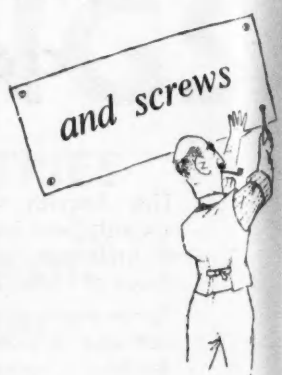

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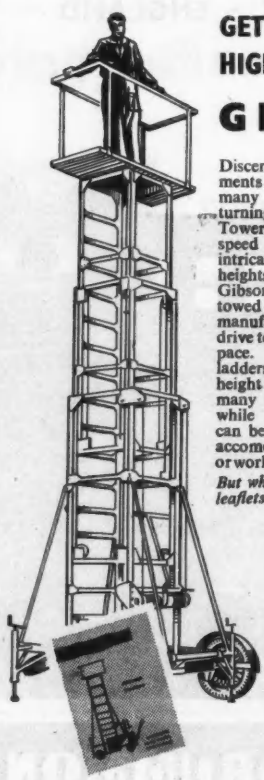
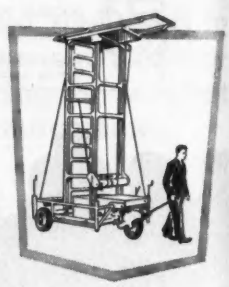


GETTING DOWN TO IT IN HIGH PLACES WITH . . .

GIBSON TOWERS



Discerning Government Departments and Municipalities in many different countries are turning to Gibson Mobile Towers to meet their need for speed and safety in handling intricate maintenance work at heights.

Gibson Towers can be trailer towed or manually operated, or manufactured with an electro drive to travel at normal walking pace. Hydraulically operated ladders which reach a working height of 35 feet are fitted to many types of vehicle bodies while special vehicle designs can be supplied to give seating accomodation for repair gangs or workshops with bench fittings.

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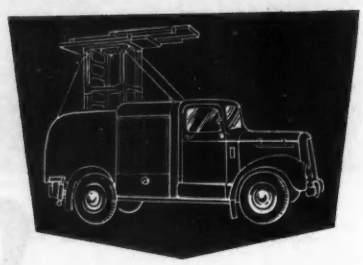

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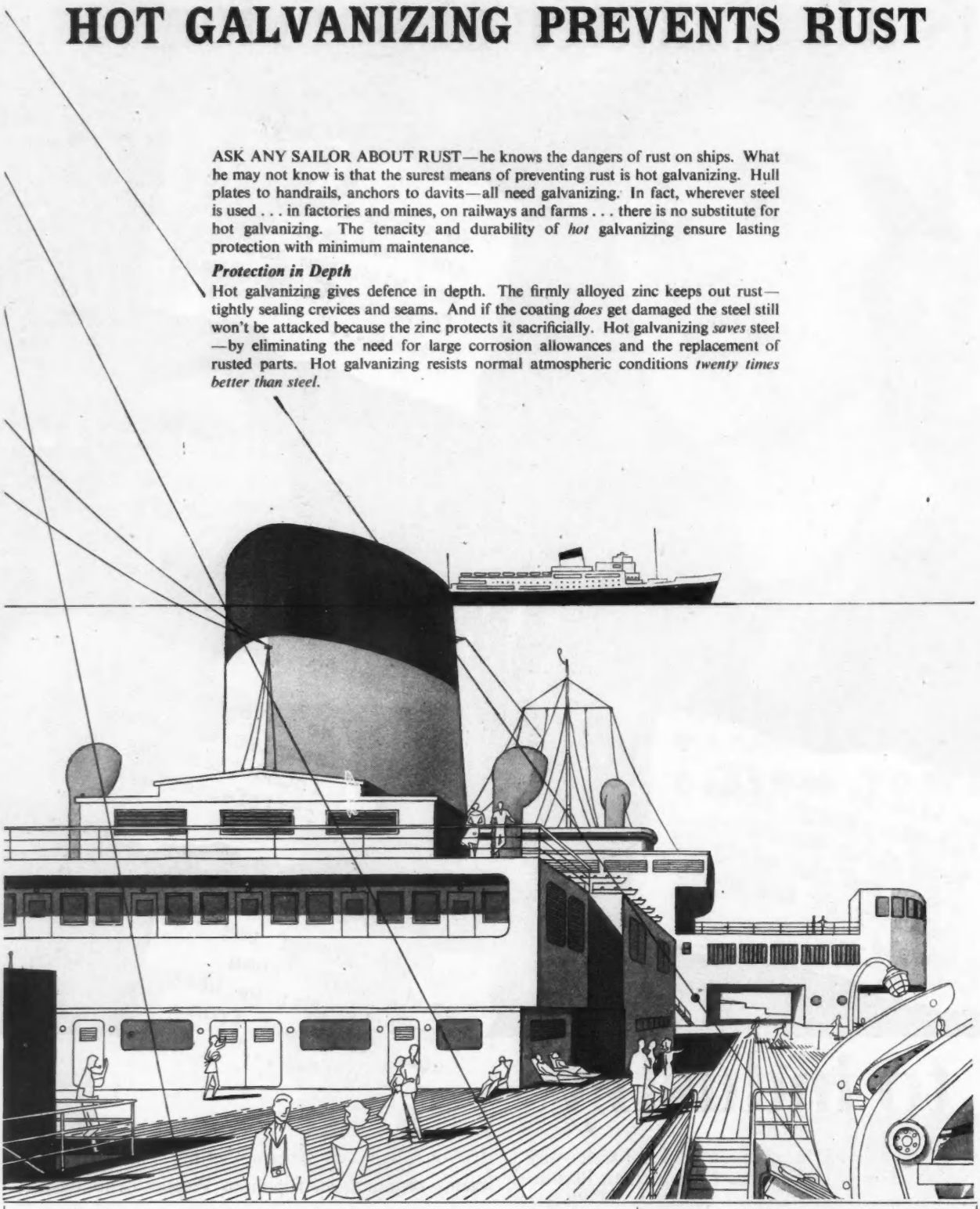

Hot Dip Galvanizers Association

The Hot Dip Galvanizers Association, a non-trading body, welcomes enquiries. Write to 34 Berkeley Square, London, W.1
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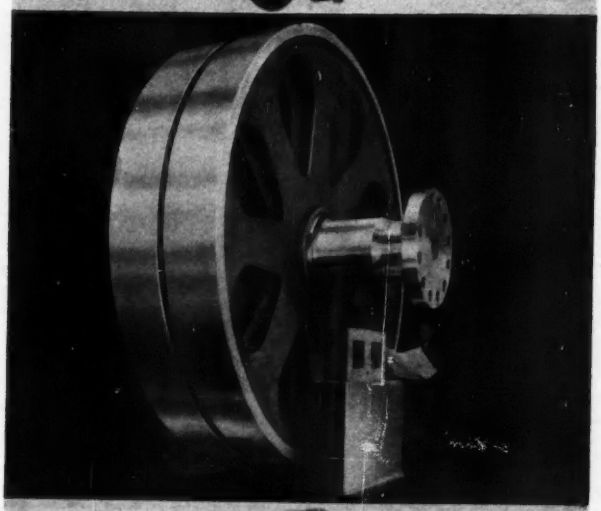

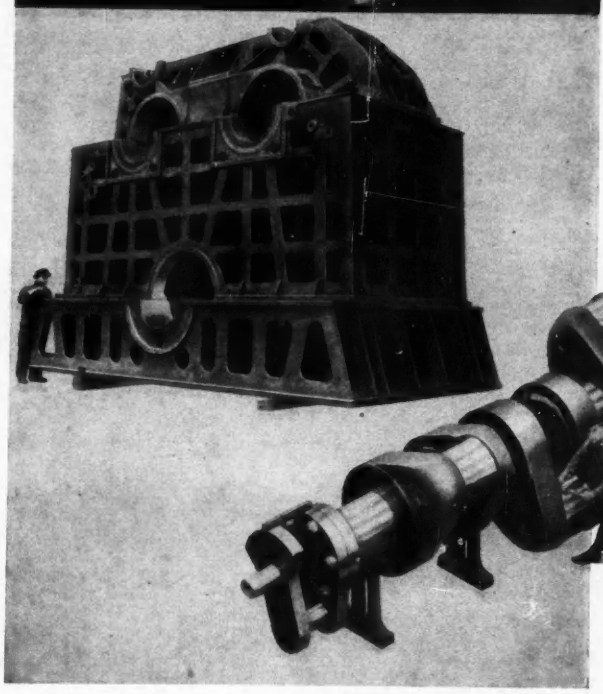

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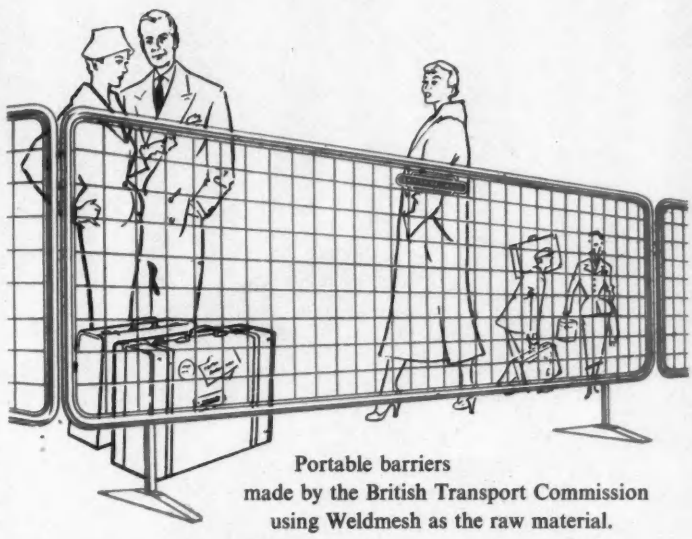

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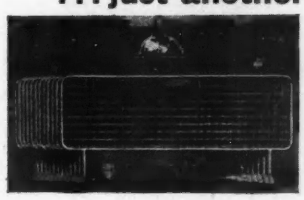

Weldmesh

WELDED STEEL WIRE MESH

Showing twelve barriers being transported by Scooter Truck.

Weldmesh *is a registered trade name and is manufactured exclusively by*

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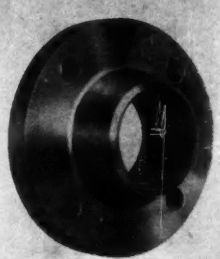

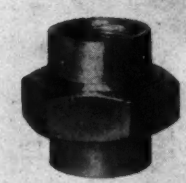

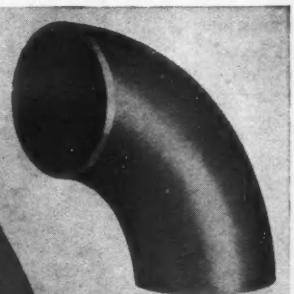

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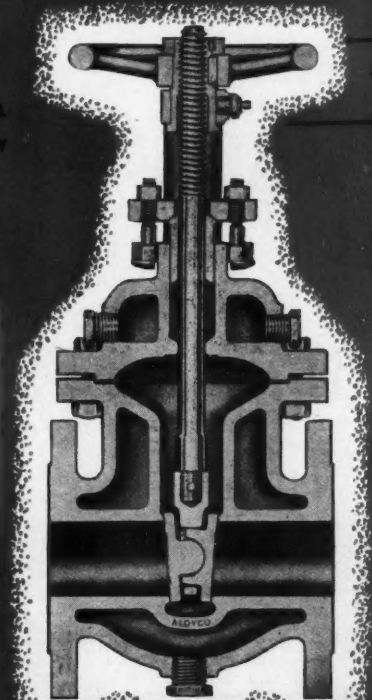

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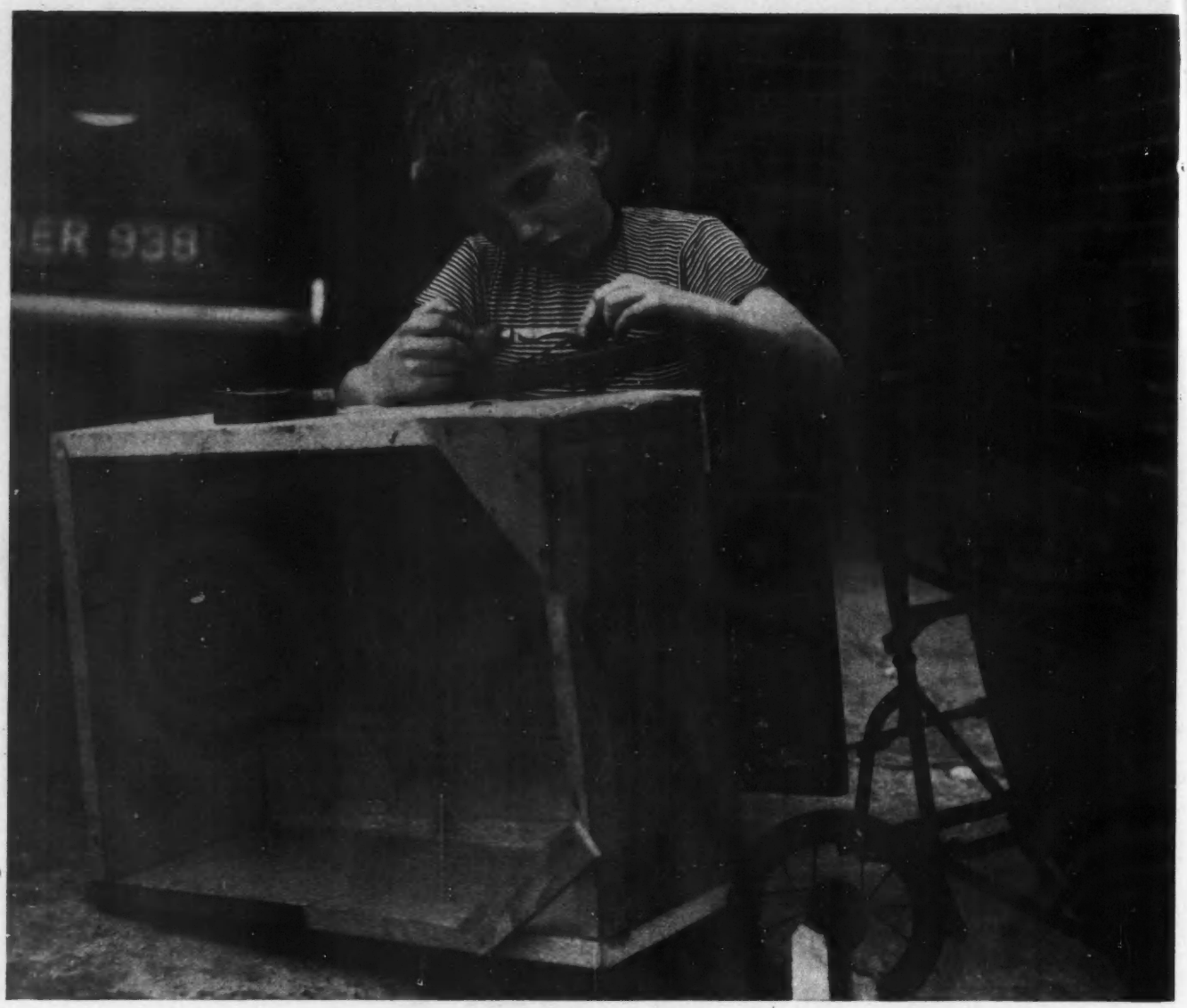

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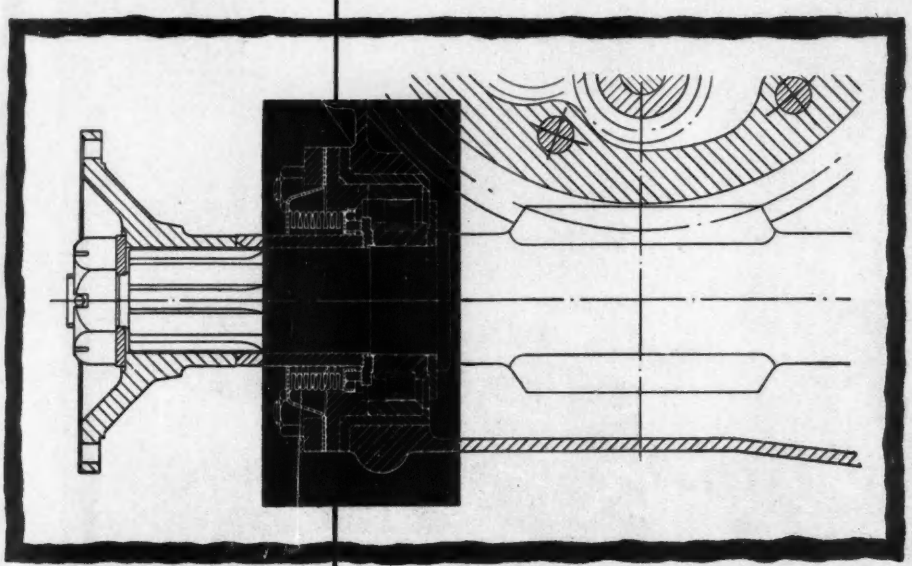

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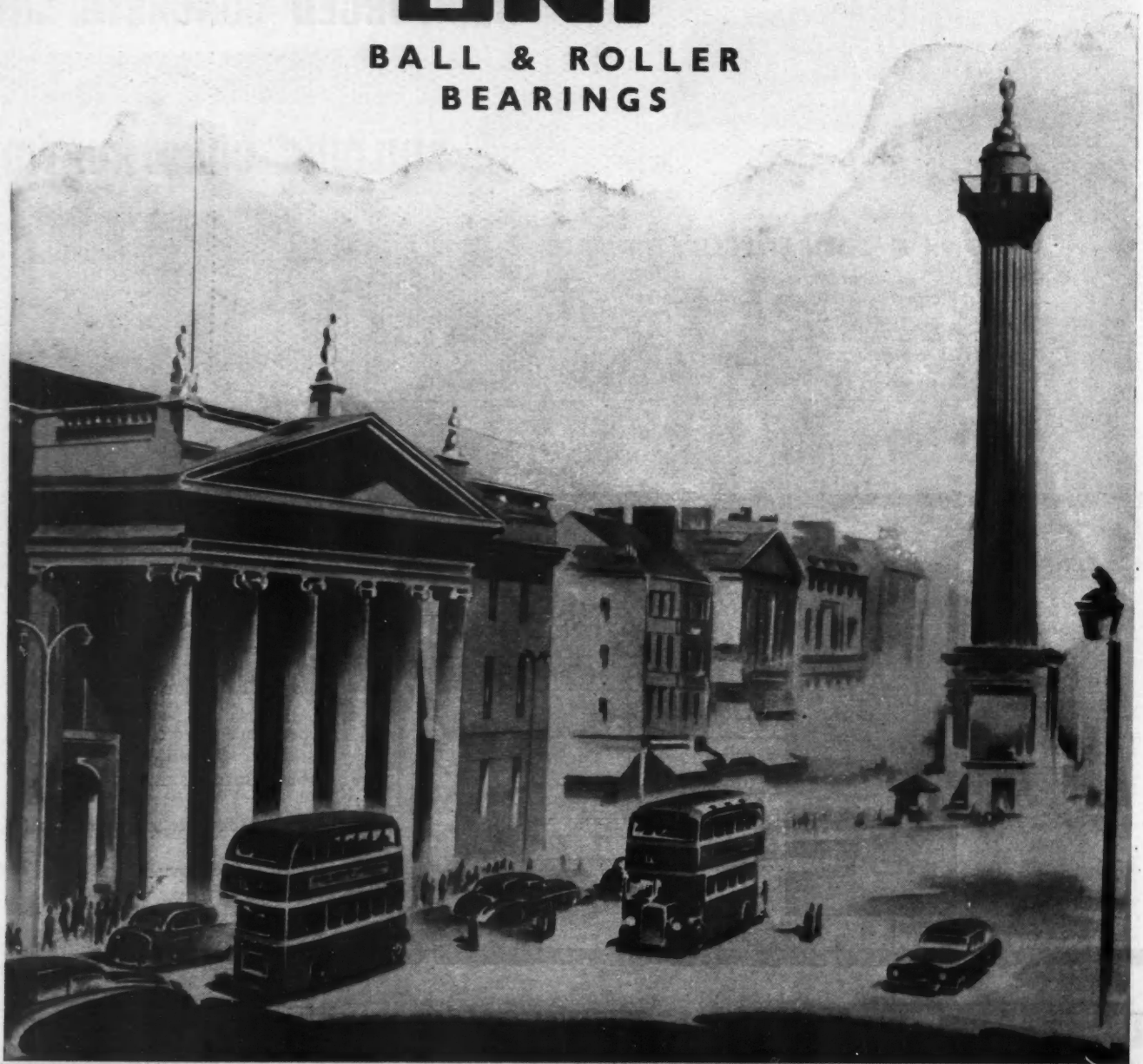

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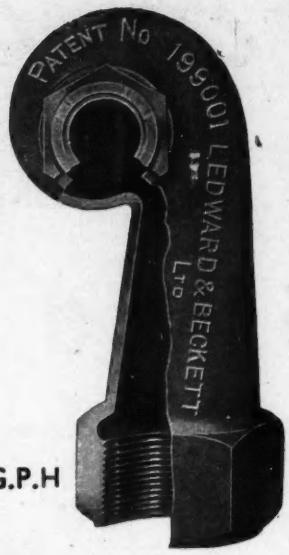

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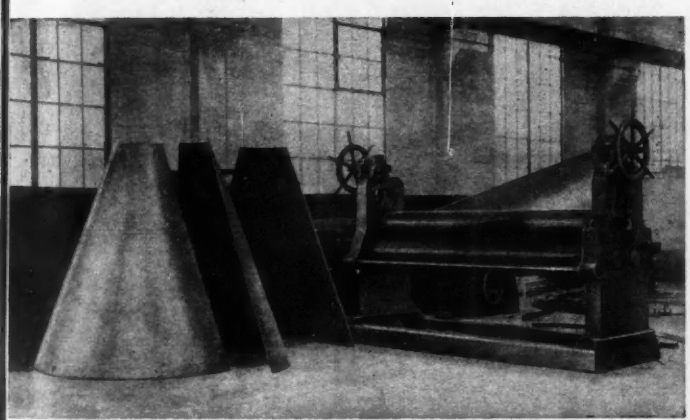

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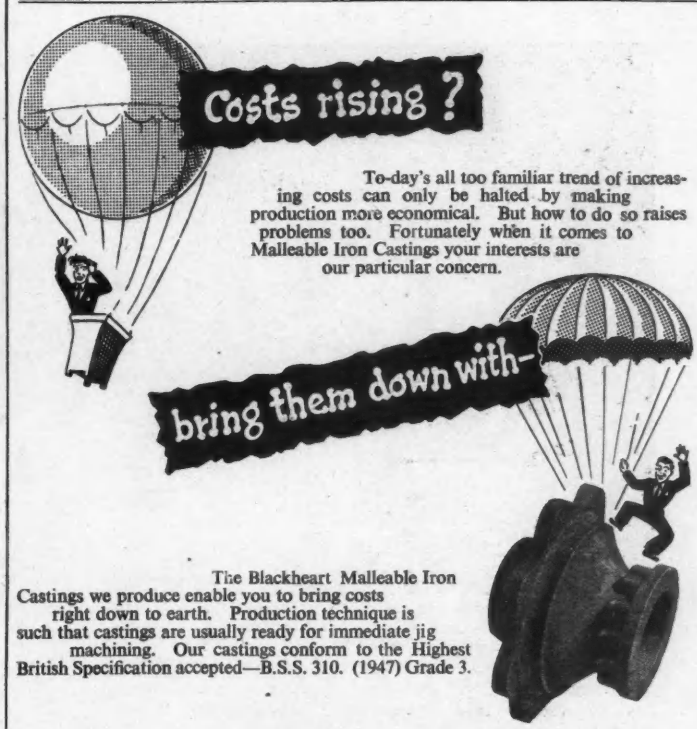

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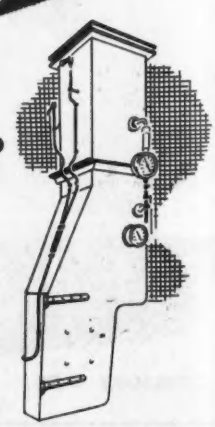
We are indebted to the British Electricity Authority and Messrs. Babcock & Wilcox for permission to reproduce the above photograph.

The photograph shows the controlling ends of the Teleflex installation of ½" Industrial Controls on boilers supplied by Babcock and Wilcox at Battersea Power Station.

TELEFLEX REMOTE CONTROLS at BATTERSEA POWER STATION



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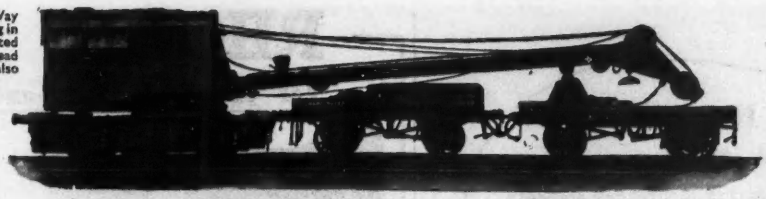

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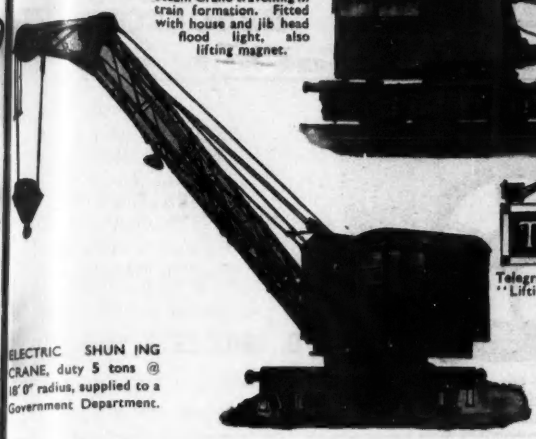
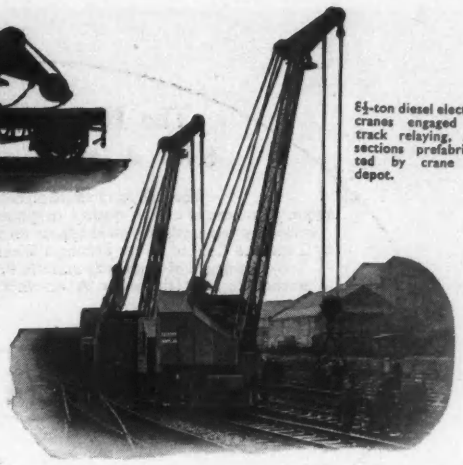


ELECTRIC SHUNTING CRANE, duty 5 tons @ 18' 0" radius, supplied to a Government Department.



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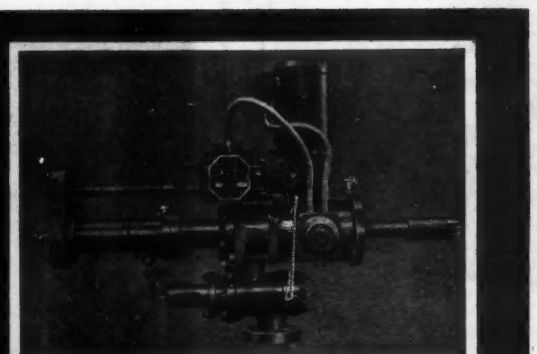
Further information is given in our publication No. CBL. 1954 which will be supplied on application.



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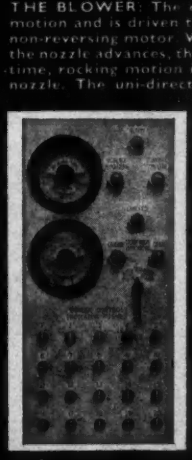

AND THE CONTROL PANEL Simple controls to operate the automatic sequence are grouped on this small unit which takes up little space on the main boiler control panel.

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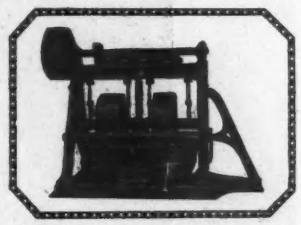

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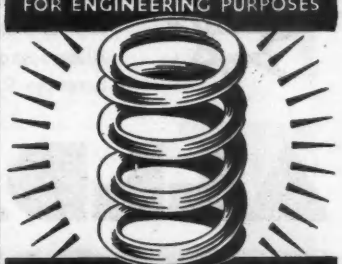

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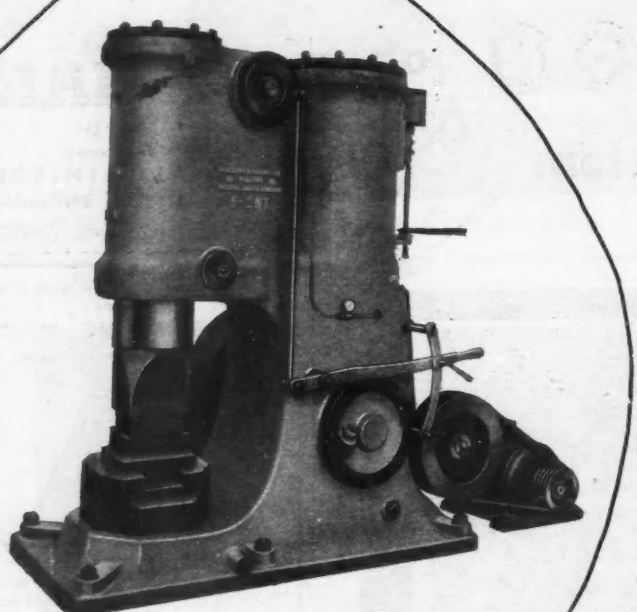

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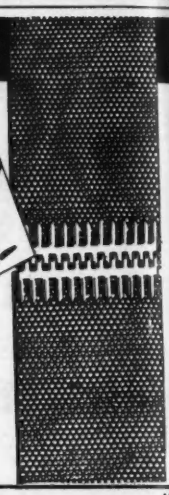

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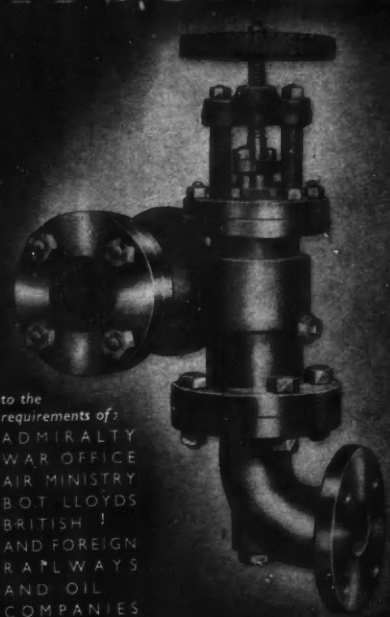

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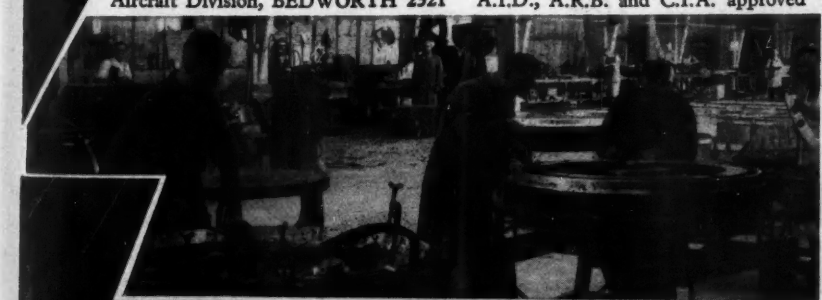

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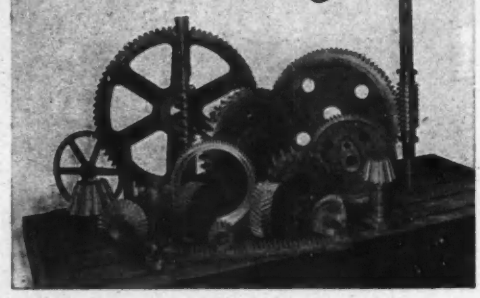

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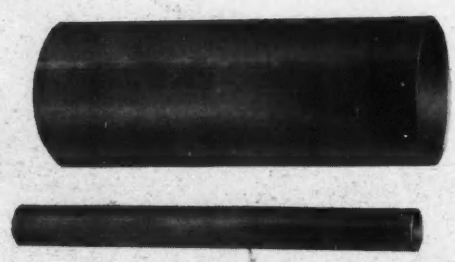

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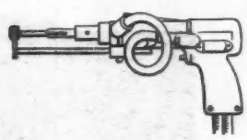

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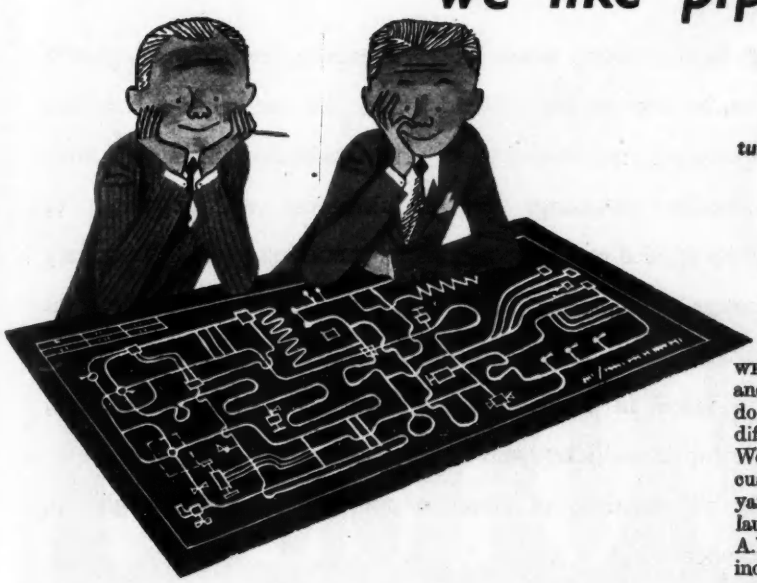

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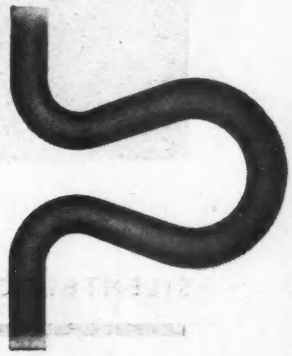

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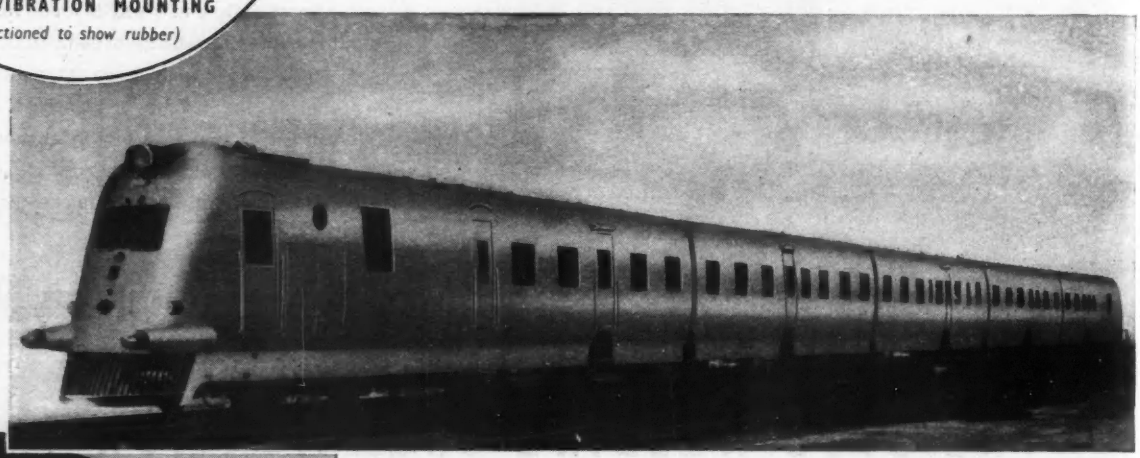
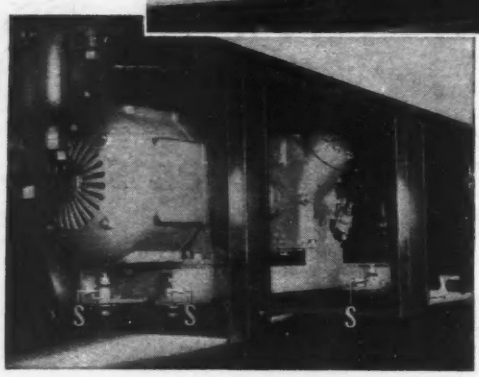
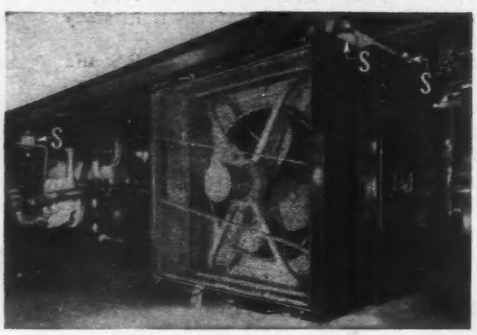


One of the diesel-electric five-coach articulated trains built for Egypt. Main contractors: The English Electric Export & Trading Co. Ltd. Designers and Constructors of mechanical parts and coachwork: The Birmingham Railway Carriage & Wagon Co. Ltd. Auxiliary installations on these exceptionally smooth riding, quiet running trains are mounted on Silentbloc units. Side-stabilizers manufactured by the Andre Rubber Co. (A Silentbloc company) are fitted to the bogies.



J. Stone & Co.'s Compressor & Condenser for the air-conditioning equipment on the English Electric five-coach sets are flexibly supported on Silentbloc mountings, indicated by letter 'S'.

Above: The Compressor. Below: Condenser & Fan.



● Less vibration means less maintenance, fewer repairs, greater comfort for passengers and longer life for motors, auxiliary equipment, mechanical parts and coachwork. Silentbloc anti-vibration mountings provide designers with a range of easily applied resilient elements for mounting main and auxiliary motors, radiators, compressors and other installations, instrument panels, bodies and side-panelling. Silentbloc flexible bearings are fitted in resilient gears designed by English Electric, Metropolitan-Vickers and Alfred Wiseman.

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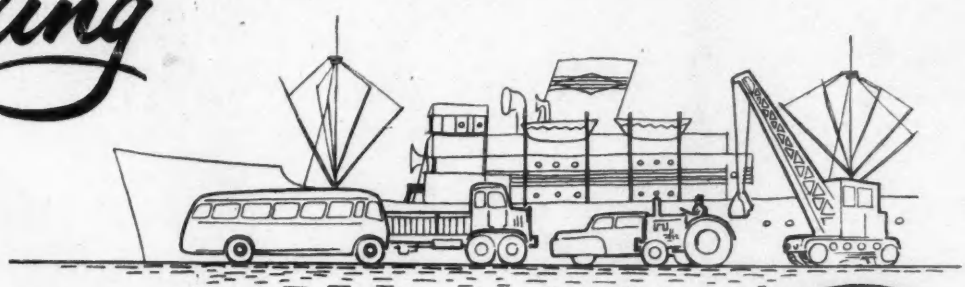

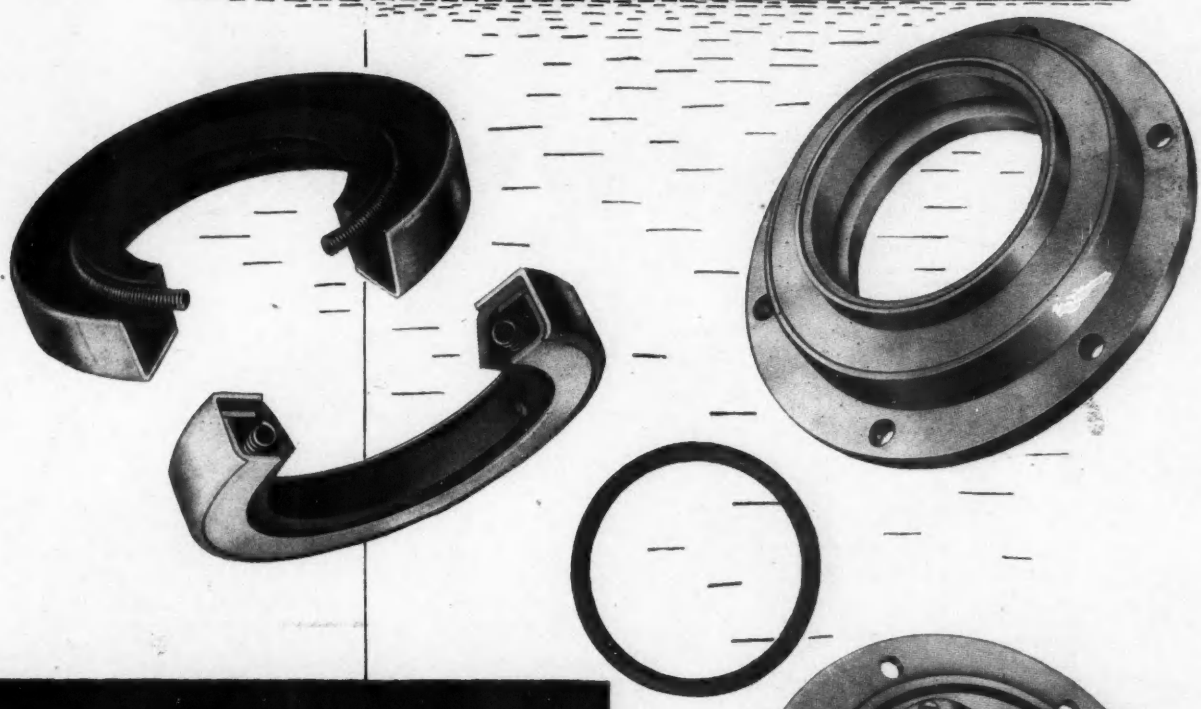

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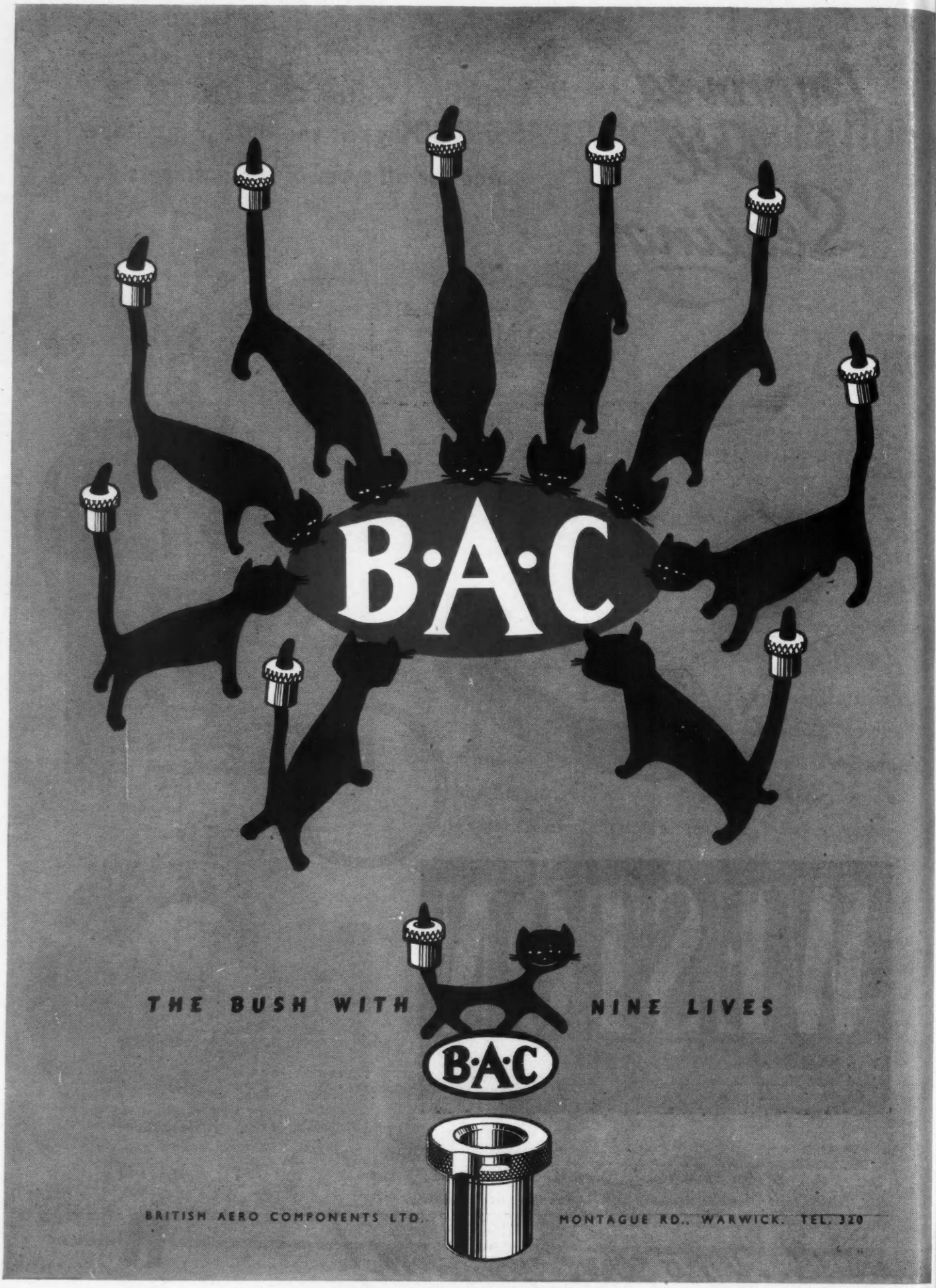
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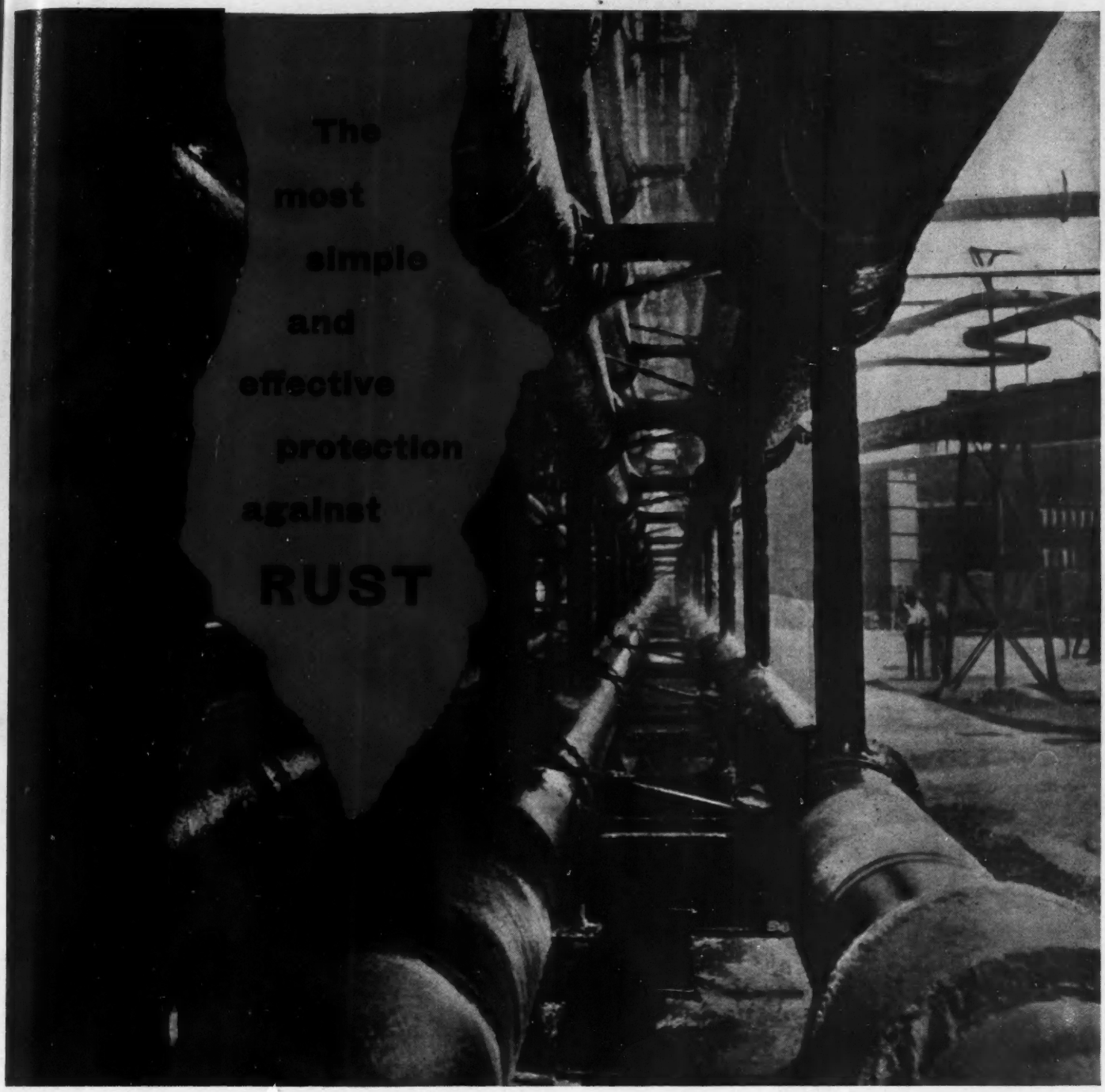

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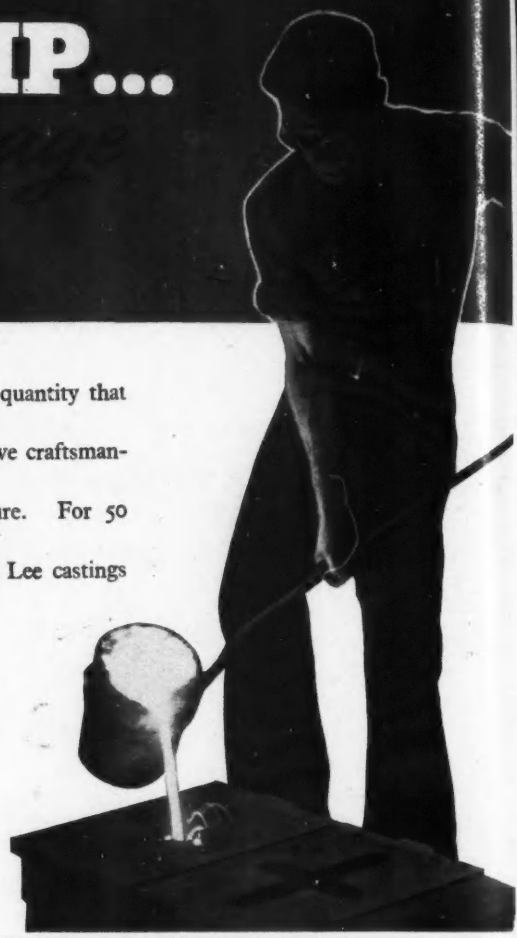

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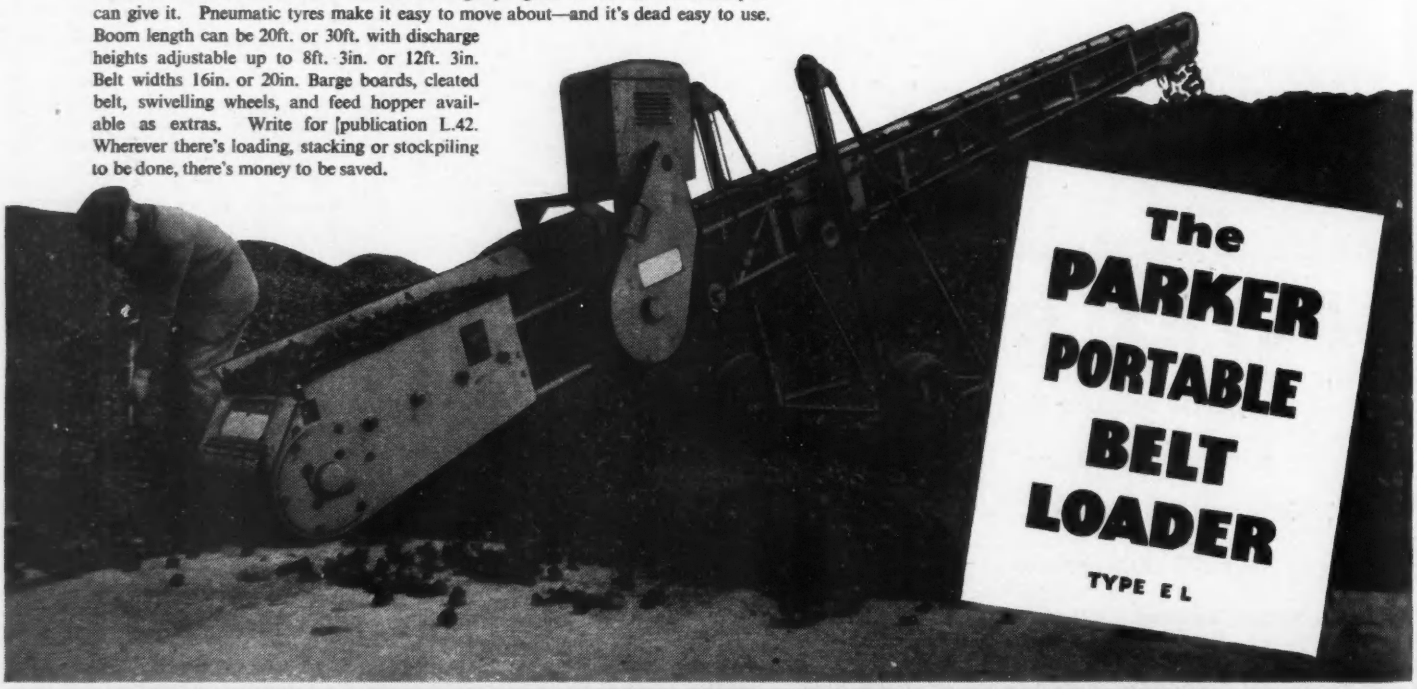

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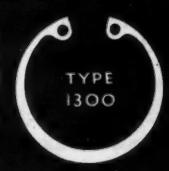

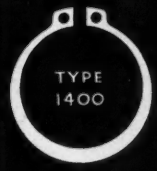

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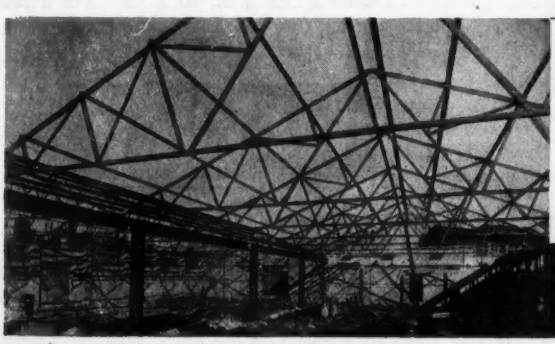

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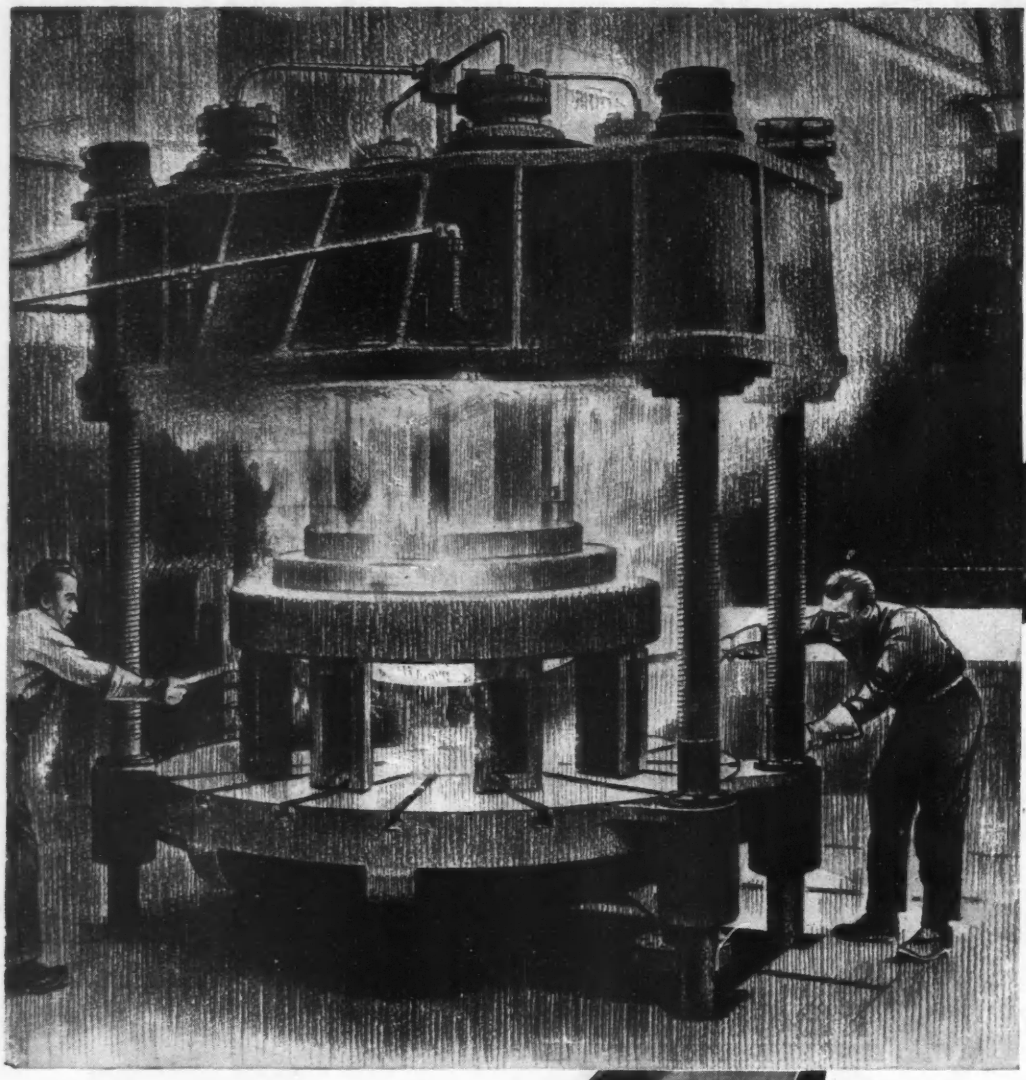

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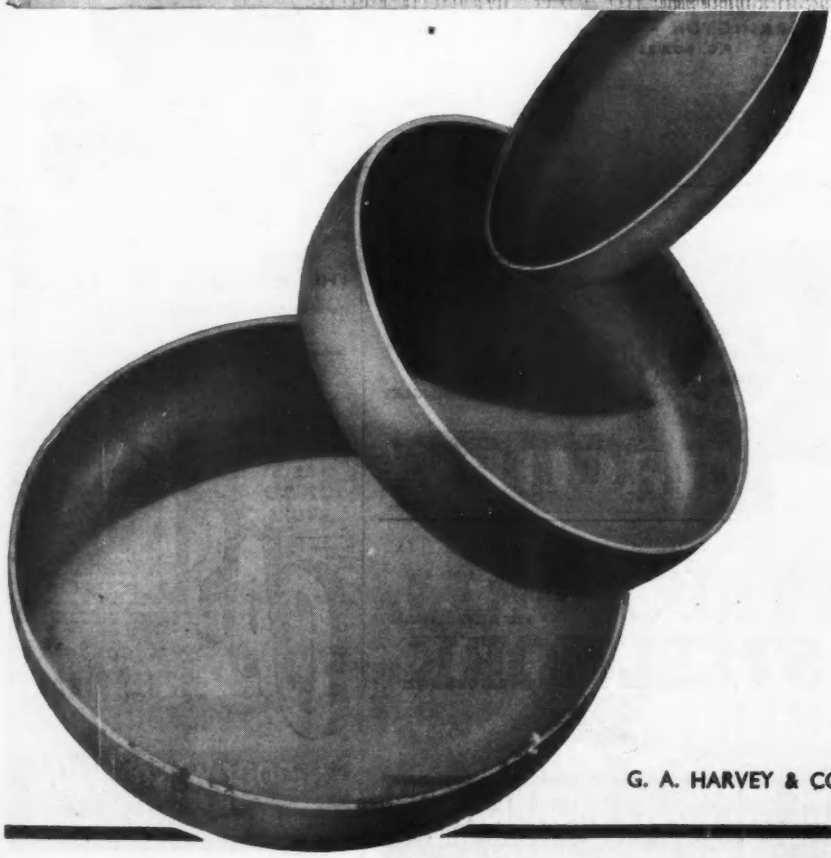

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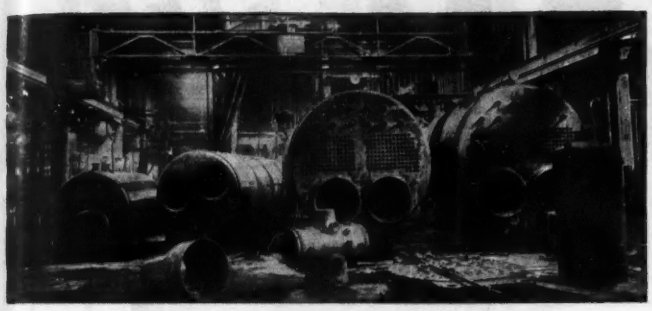

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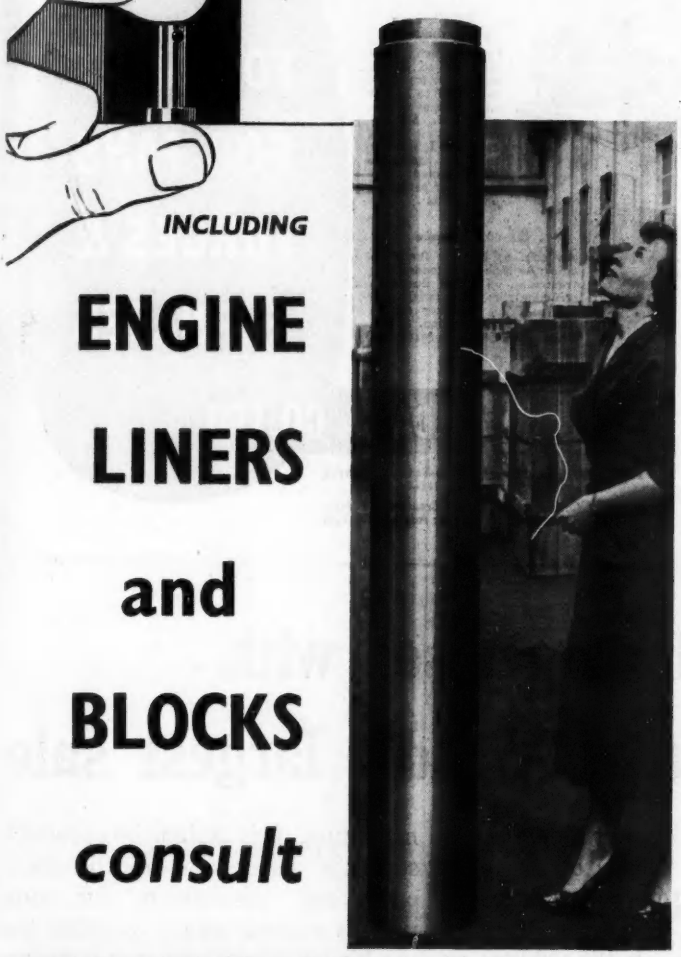

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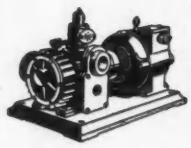

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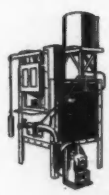

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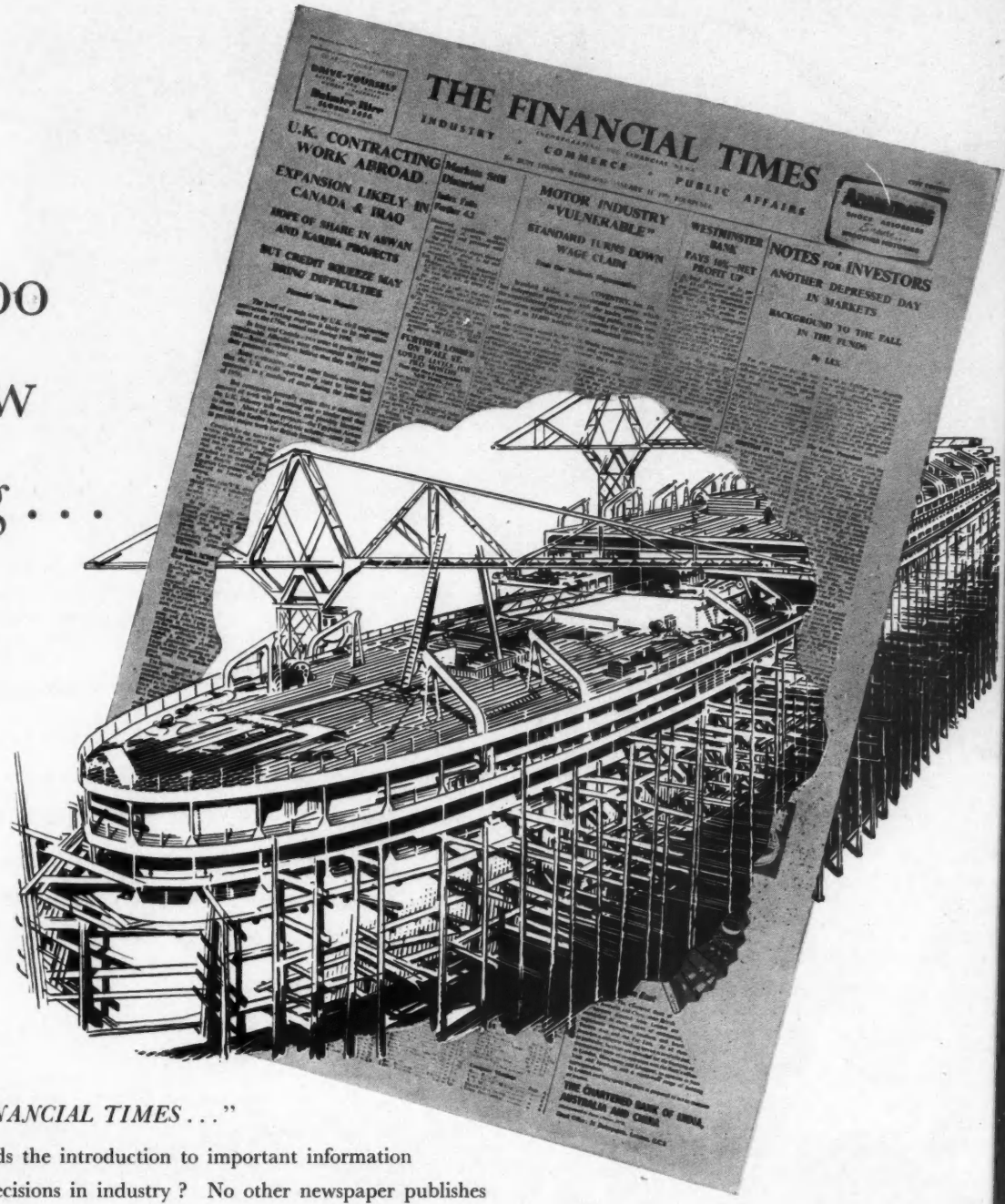
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The extracts quoted are from a letter written by E. Loades, Esq., Managing Director of The Abbey Panel & Sheet Metal Co. Ltd., Coventry and Bedworth.

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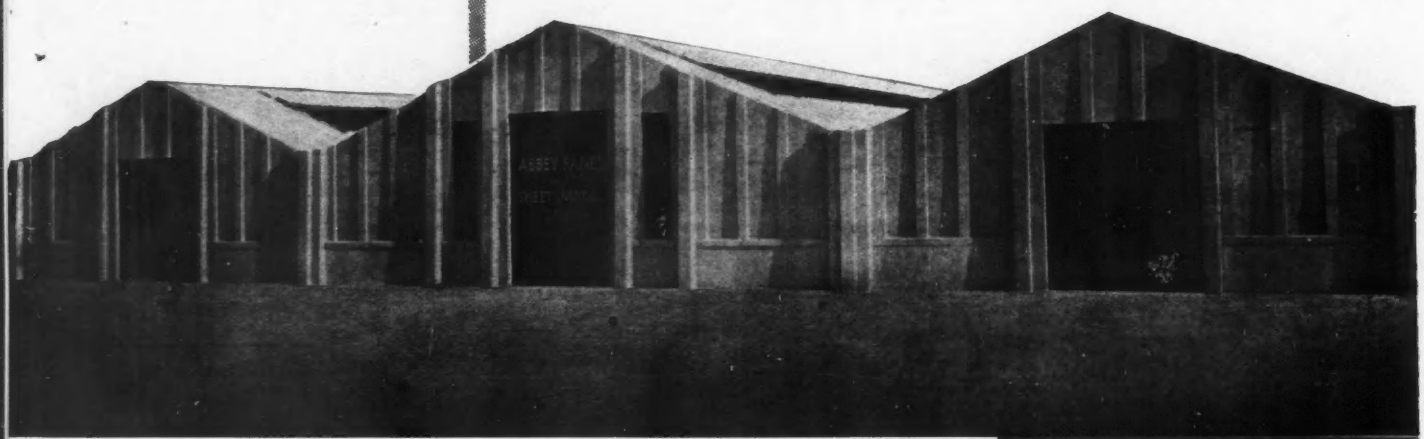

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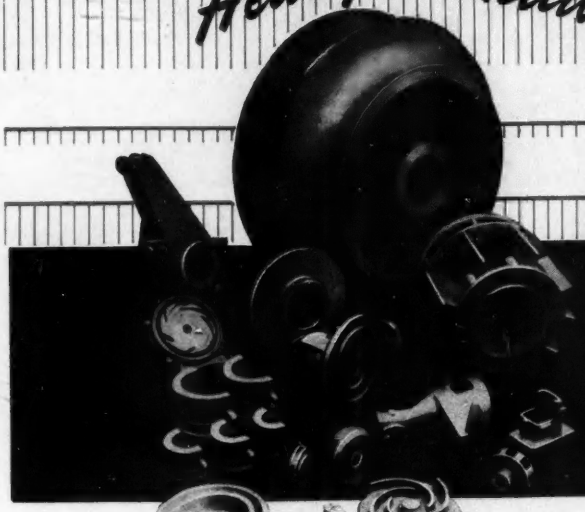

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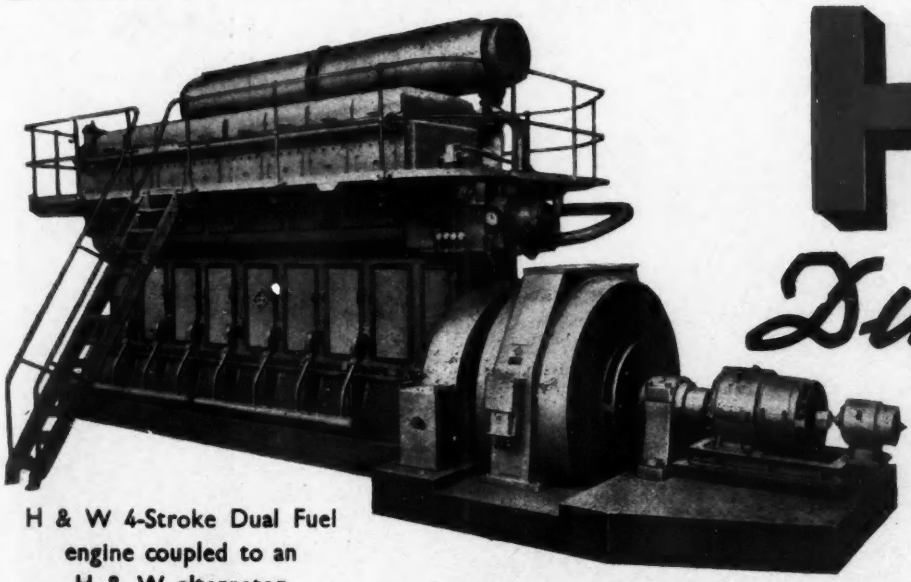

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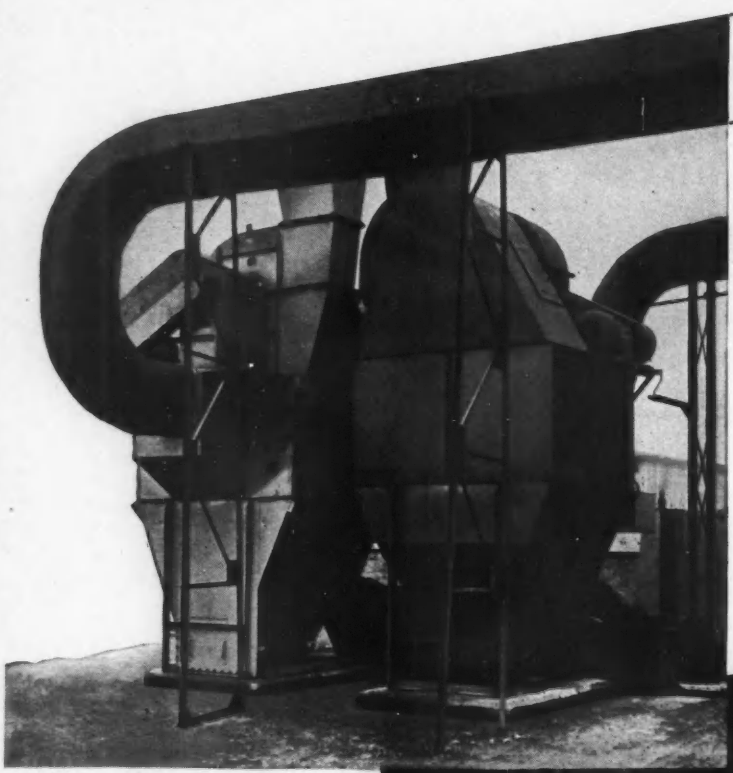

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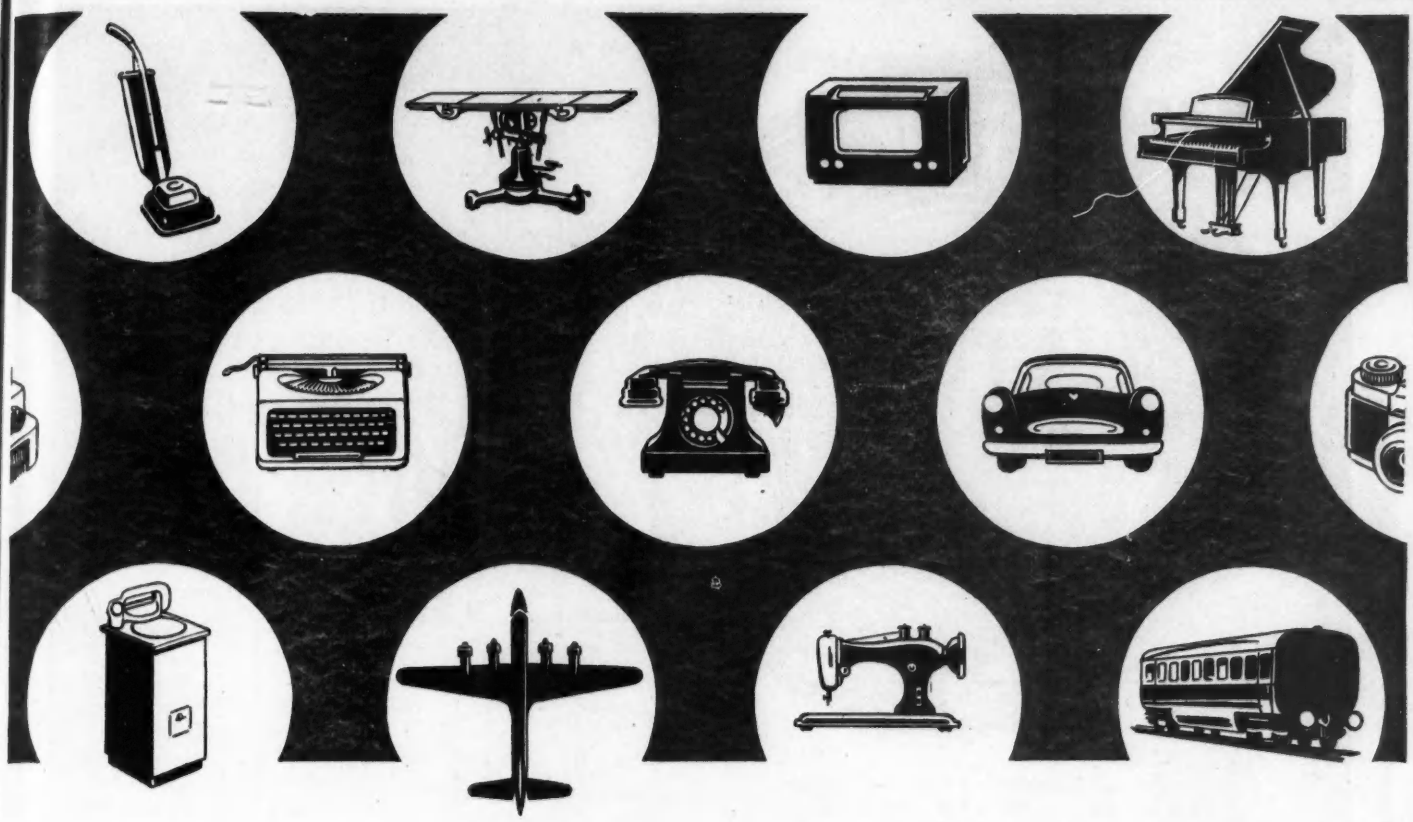

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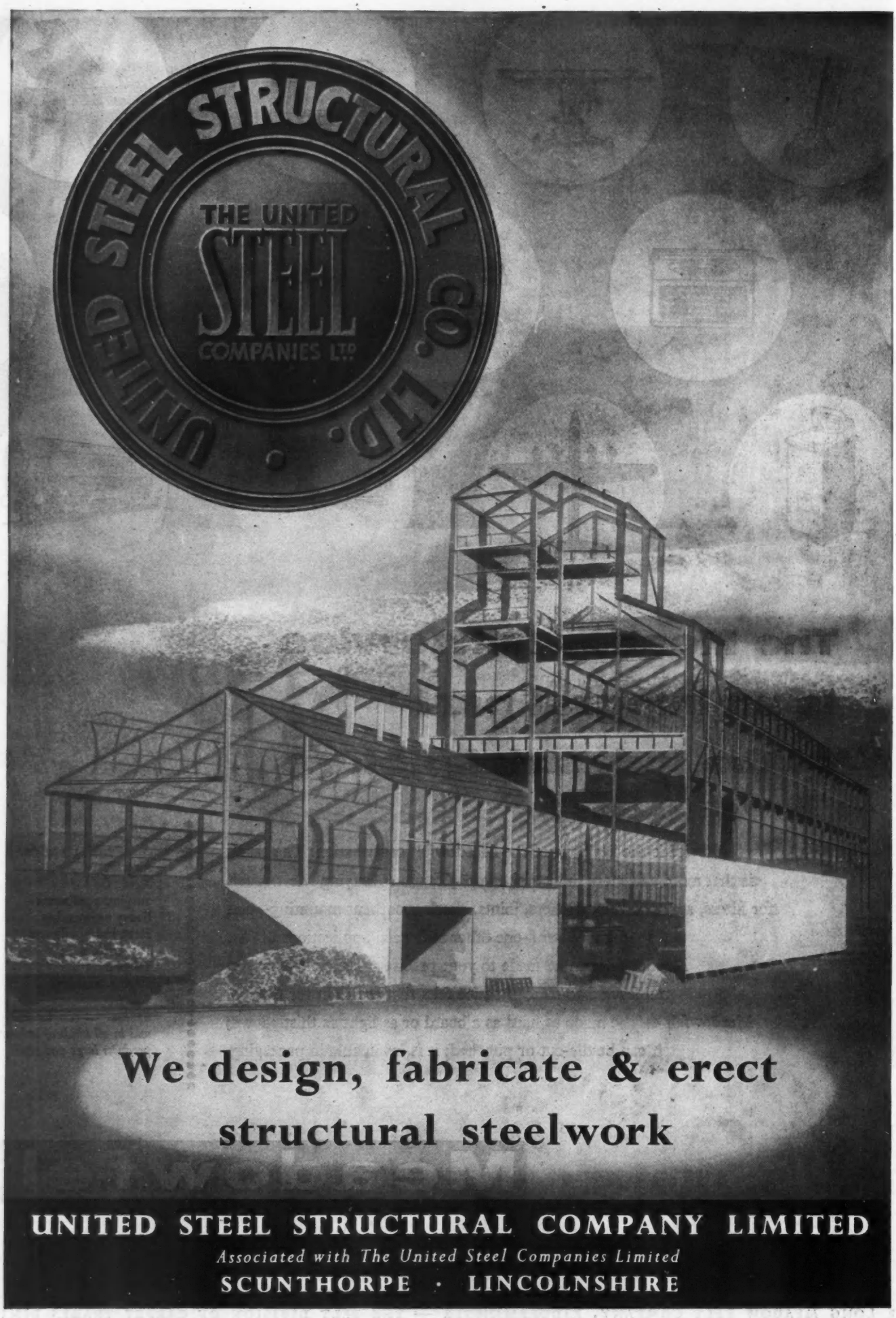
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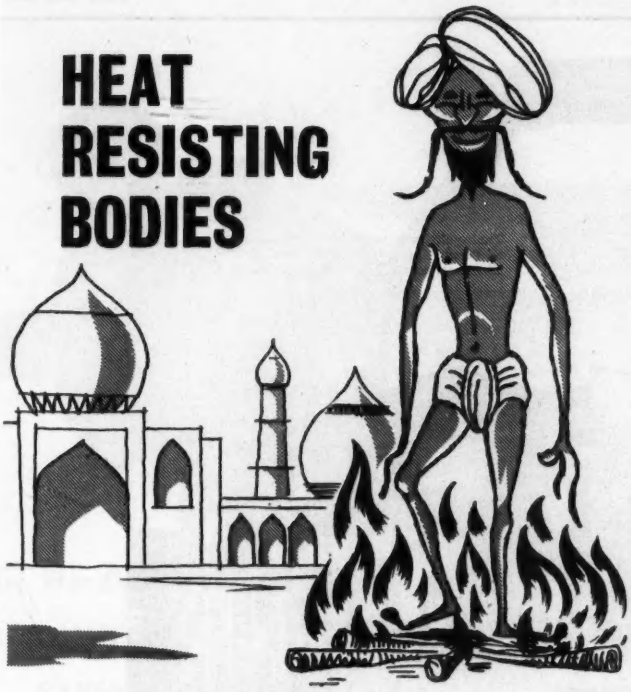

The heat-resisting properties of 71C, one of several special duty ceramics made by Doulton, lie in the special nature of its ingredients. Vessels and containers made in 71C are recommended wherever heat is encountered in chemical processing.
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Both sections can be screwed together and fitted into the container as one unit.
Therefore, three models are available, viz.:—

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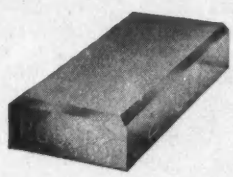
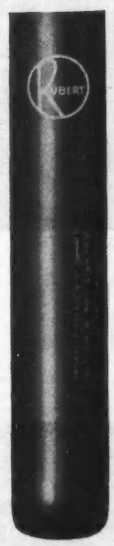
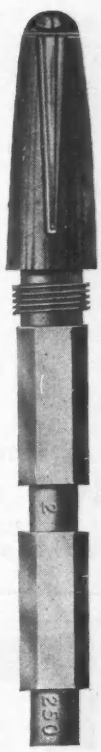
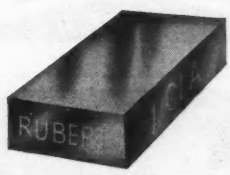
Model 41—63 to 1,000 Micro" C.L.A. inclusive	£4.10.0
Model 42—1 to 1,000 Micro" C.L.A. inclusive	£8. 0.0







We also make Surface Roughness Standards in stainless steel, hard carbon steel, and glass to finishes from 1 to 1,000 Micro" C.L.A. and supply these singly or in sets. (Supplied with or without "Taylysurf" recorded graph.)



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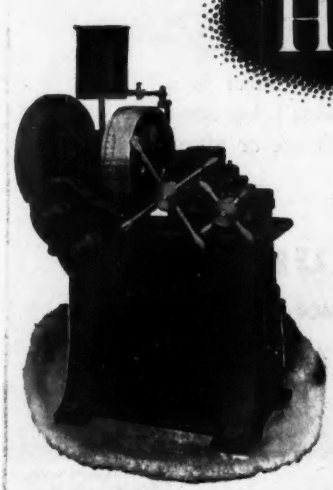

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City Architect : J. Nelson Meredith, F.R.I.B.A.

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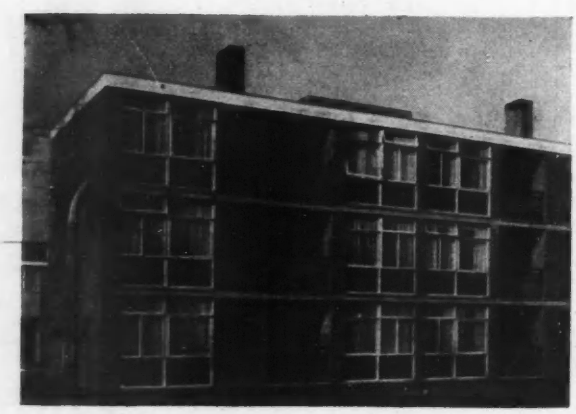
speeds construction and lowers heating costs



Timber framed wall panels in L.C.C. flats at
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Architect to the Council, Whitfield Lewis, A.R.I.B.A.,
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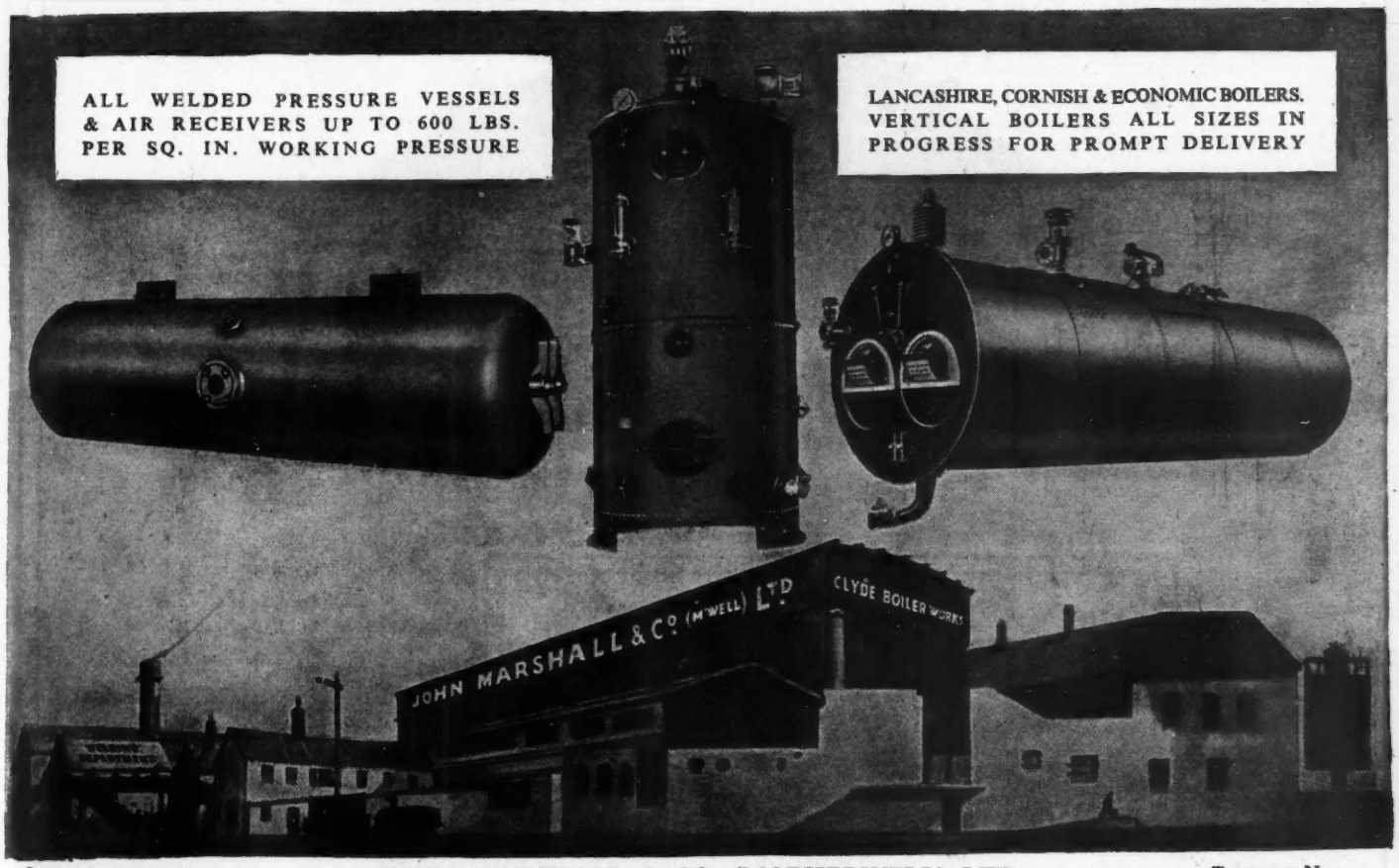

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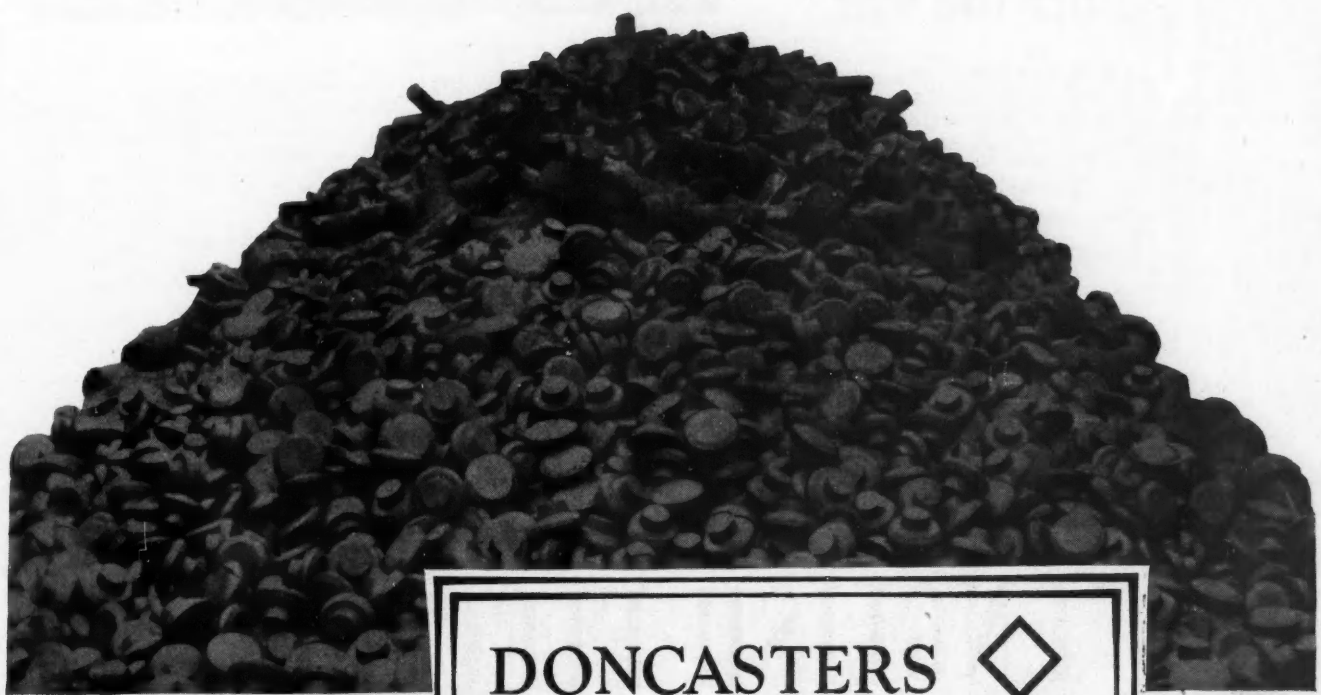

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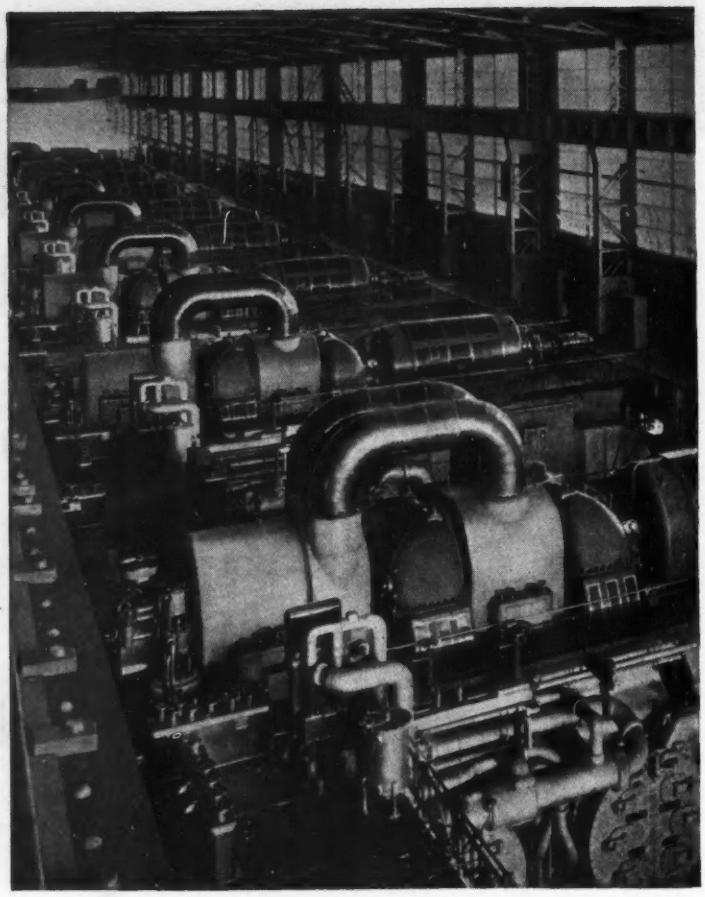

The Vierfontein Power Station of the Electricity Supply Commission of South Africa, the largest to be built in the Union of South Africa since the war, will have an ultimate generating capacity of 360 MW.

In May 1953 the first 'ENGLISH ELECTRIC' 30 MW turbo-alternator set was commissioned, and since then eight similar sets have been put into service. A tenth set is now being erected which will be followed by a further two sets now in course of manufacture.

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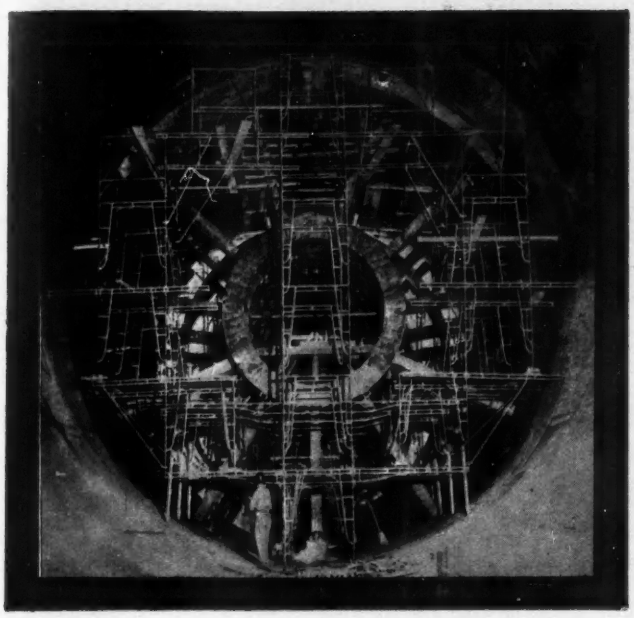
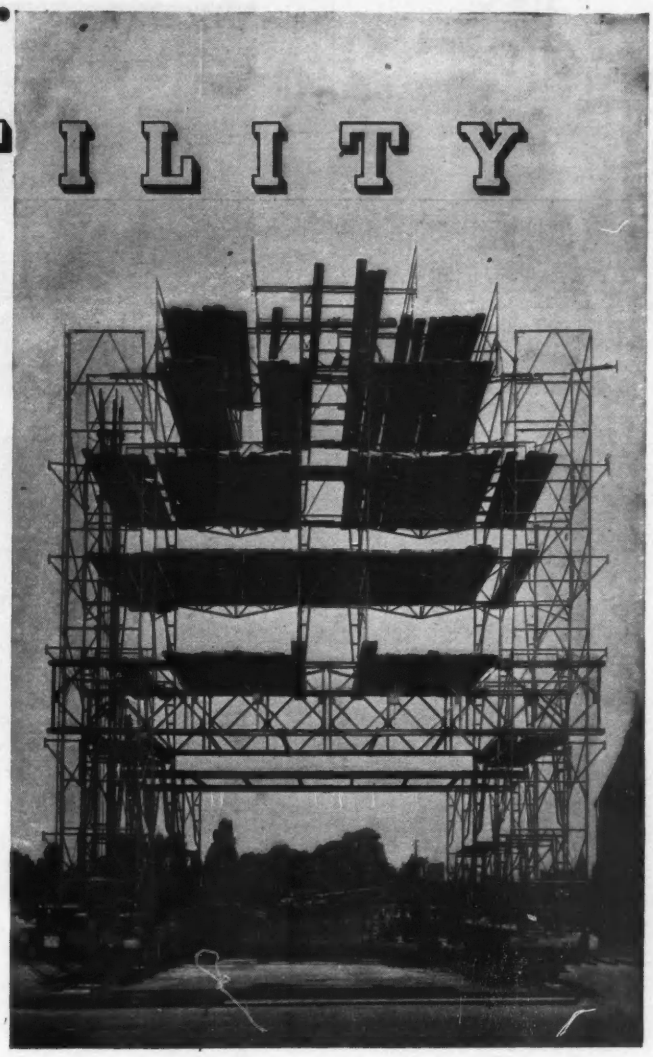


The contours of a surface do not restrict the use of the equipment, which can be assembled as quickly for the construction of a circular wind tunnel as it can for use in building an ordinary house or a large factory



A perfect example of a less usual application—a drilling stage used for drilling tunnels through rock. The stage can be advanced as tunnelling proceeds. Dimensions: 50 feet high, 35 feet wide and 30 feet long.

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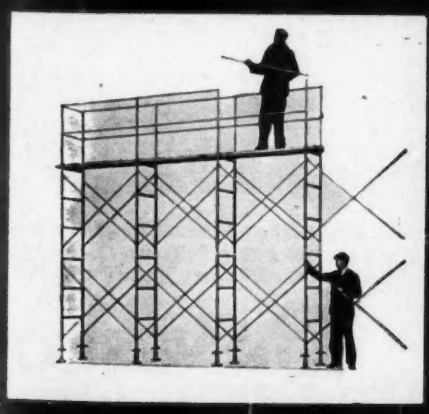

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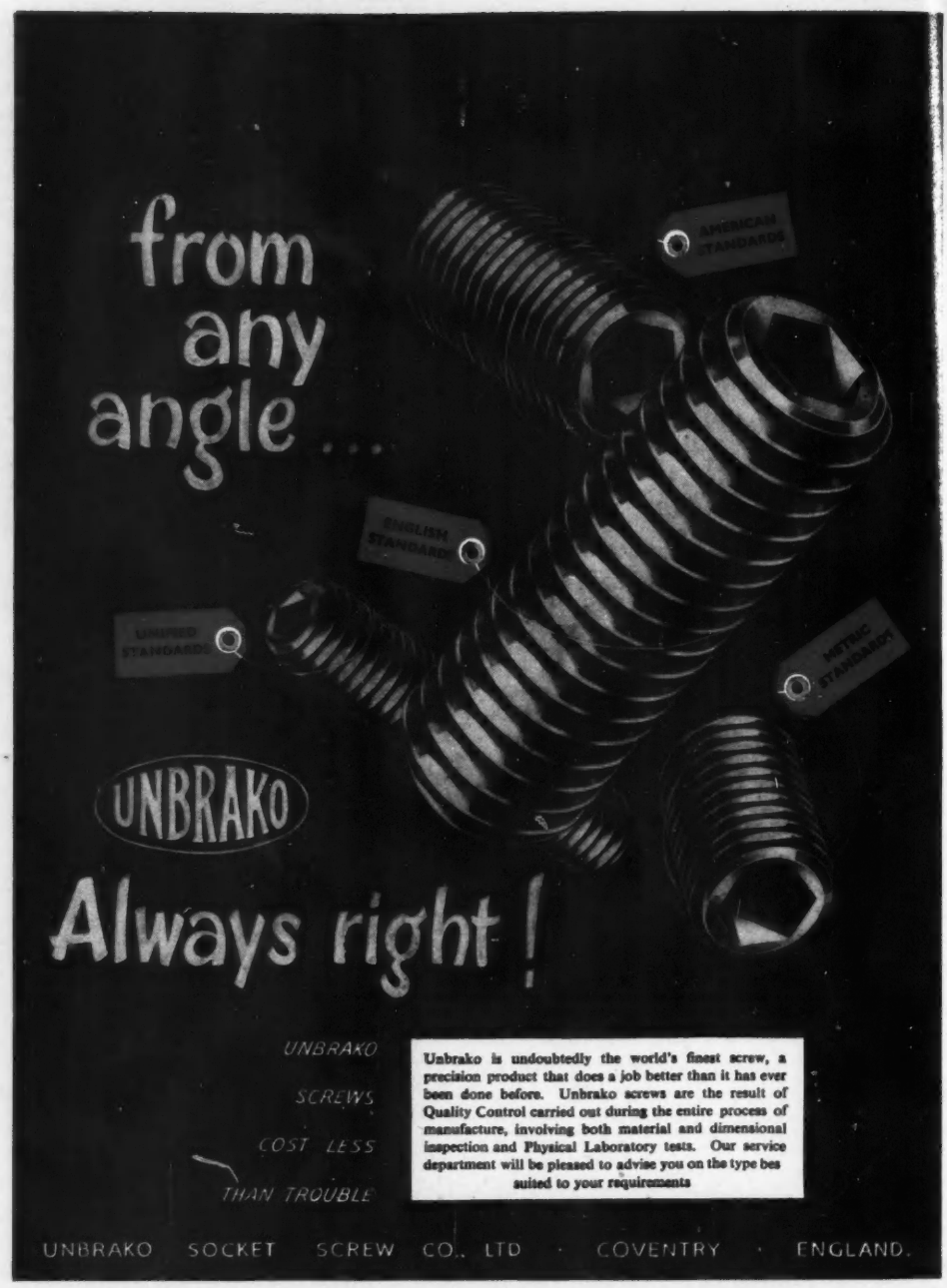
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Illustration shows 'dag' colloidal graphite being applied to the dies of a 2,000 ton horizontal extrusion press.

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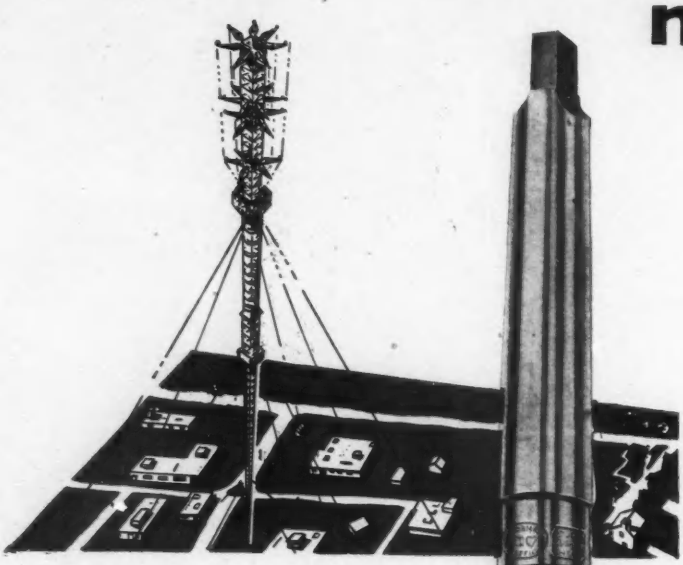

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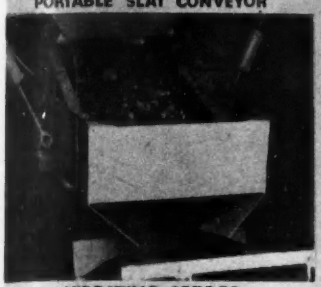
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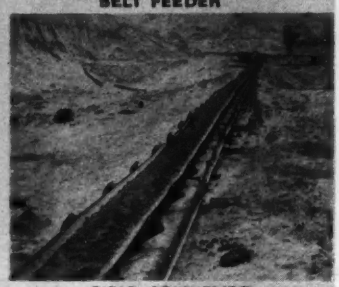
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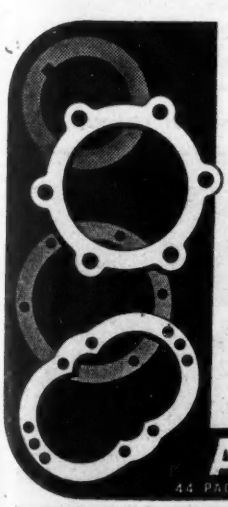

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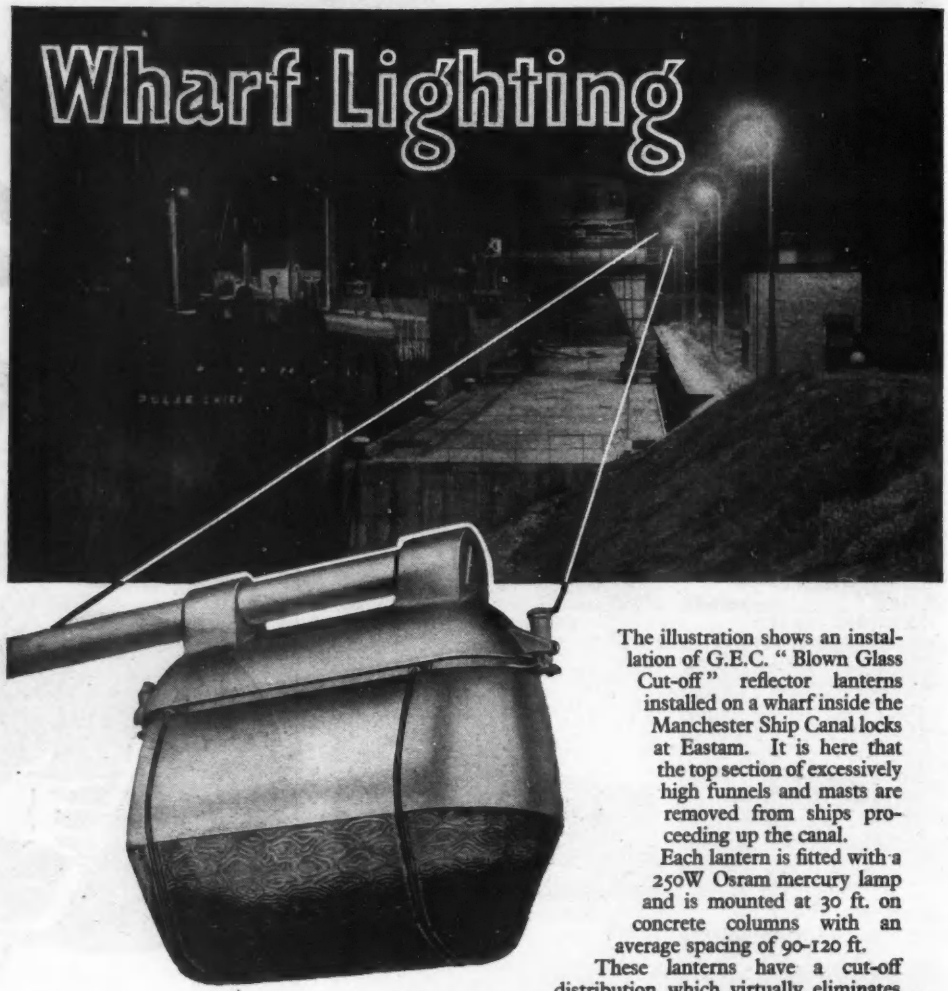

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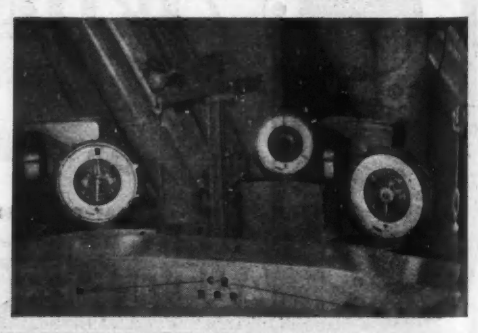

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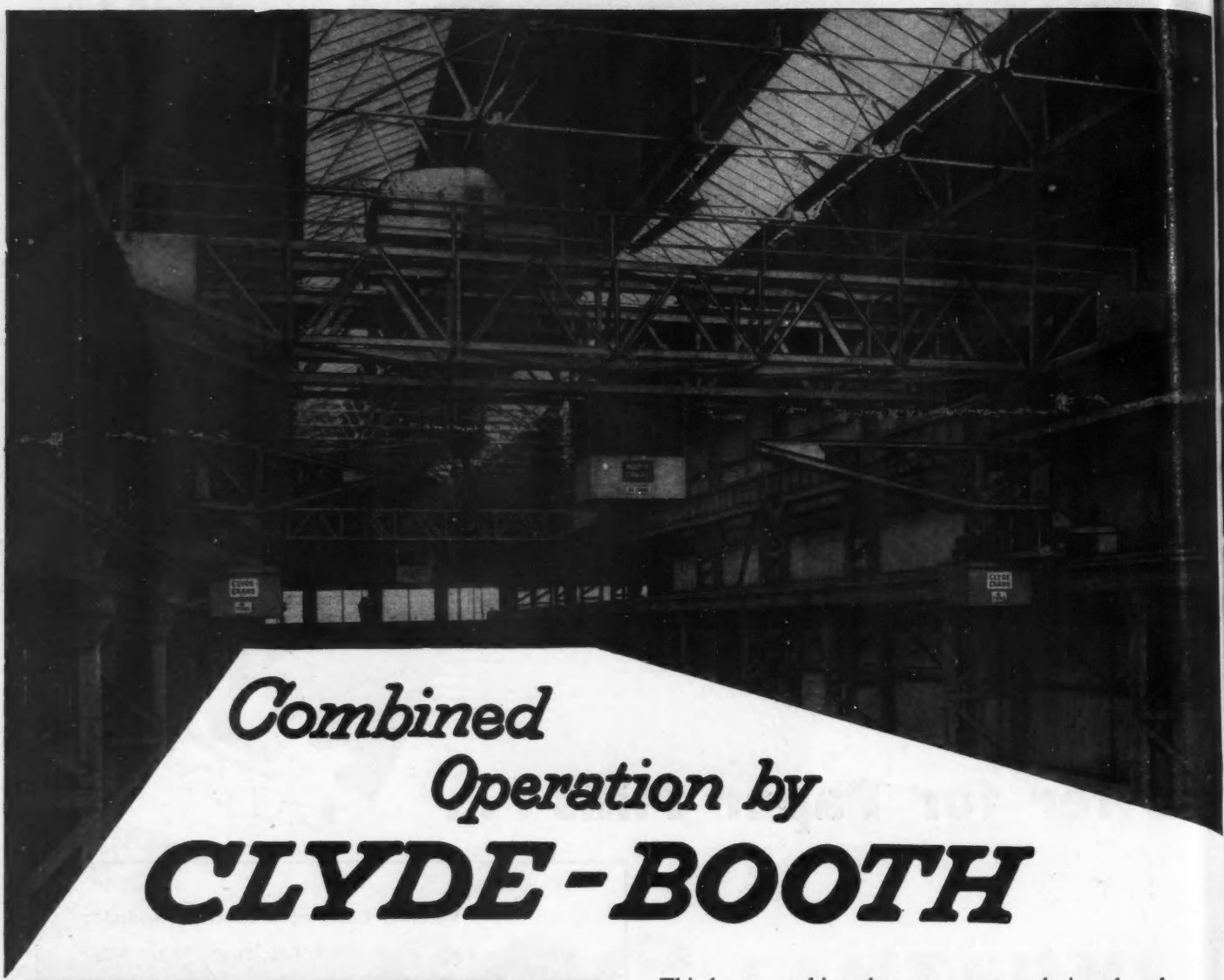

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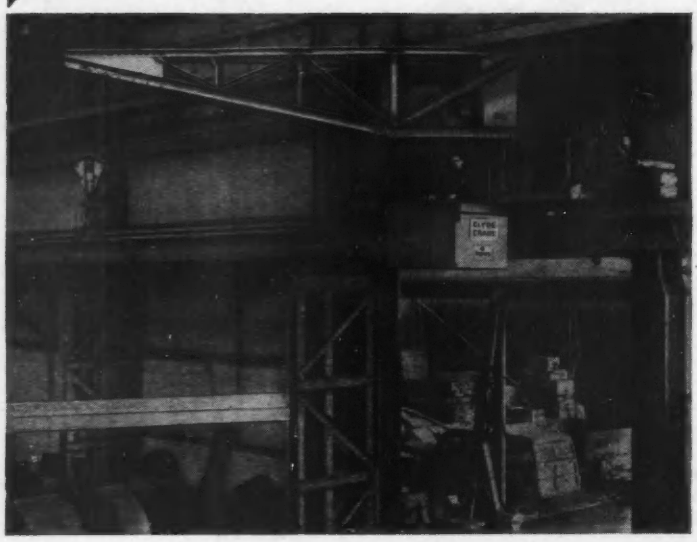

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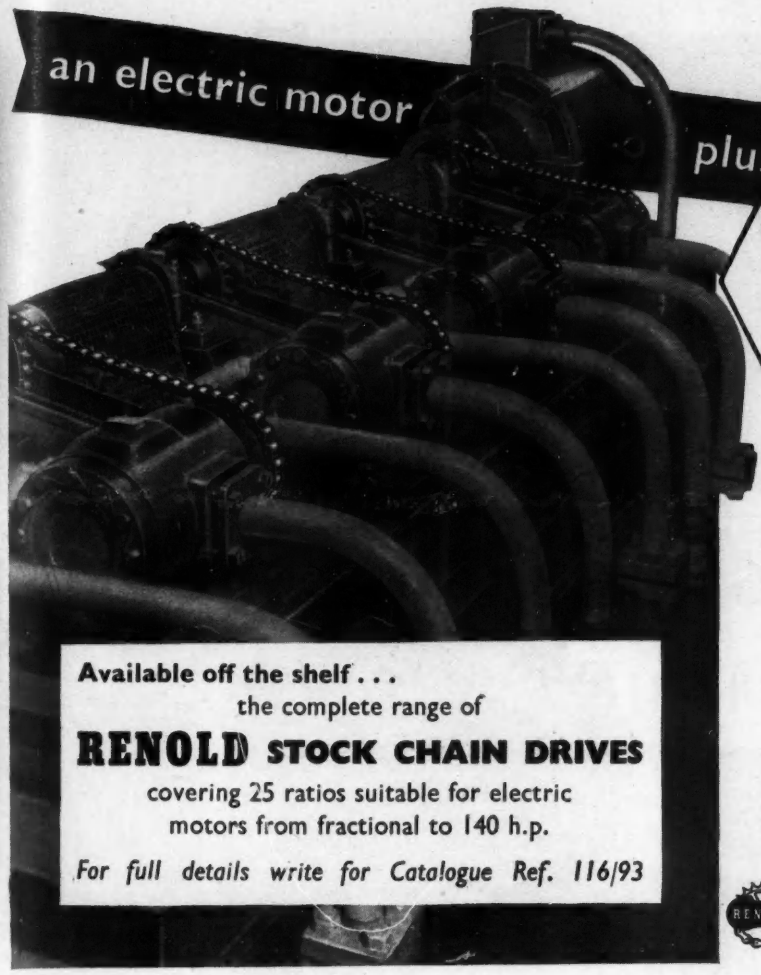

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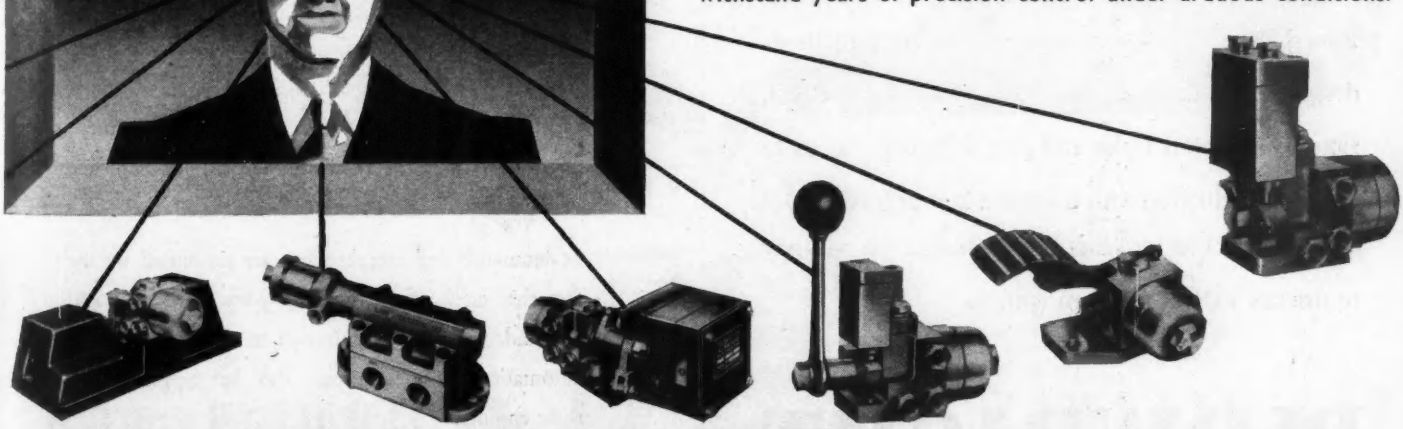

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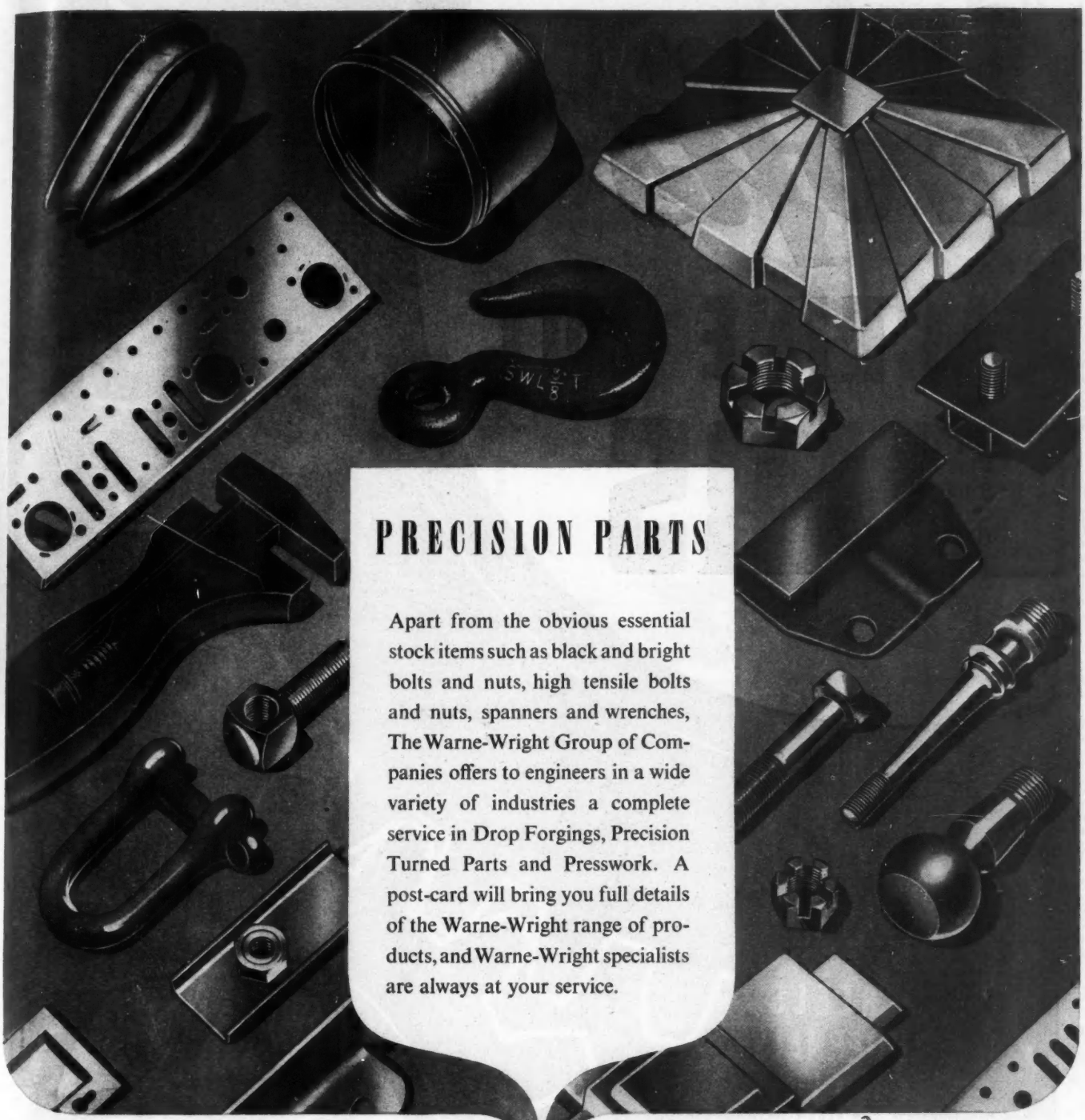

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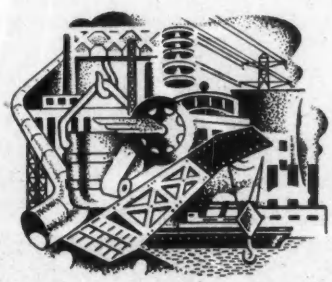

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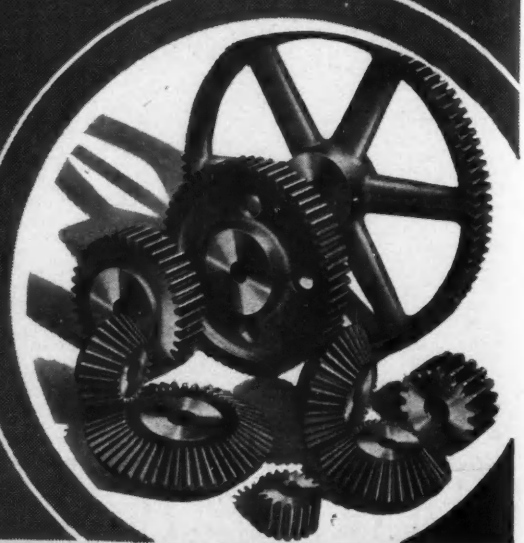

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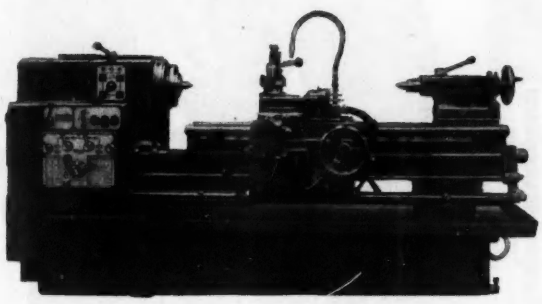

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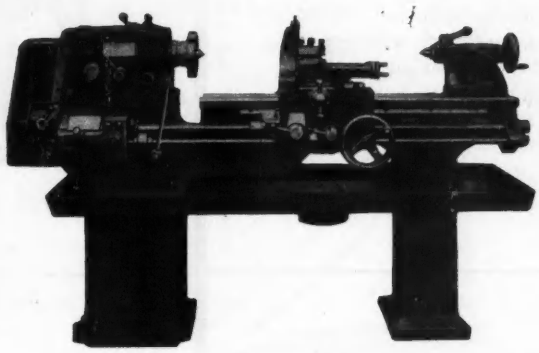

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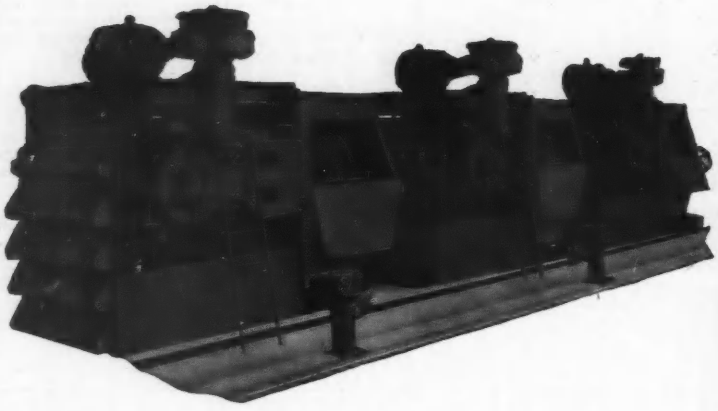

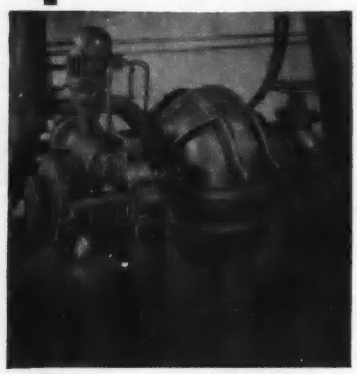

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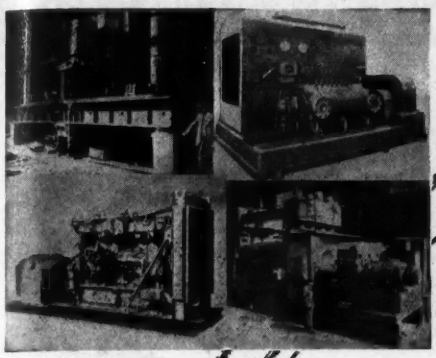

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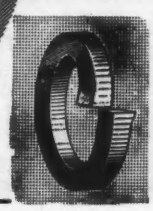

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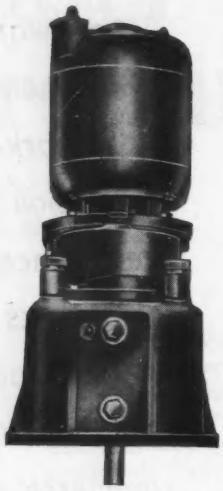

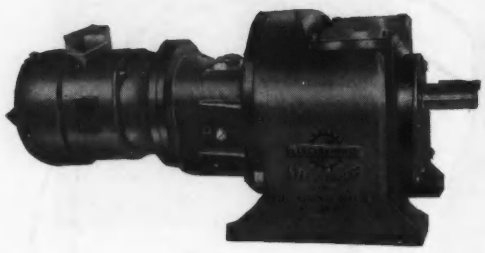

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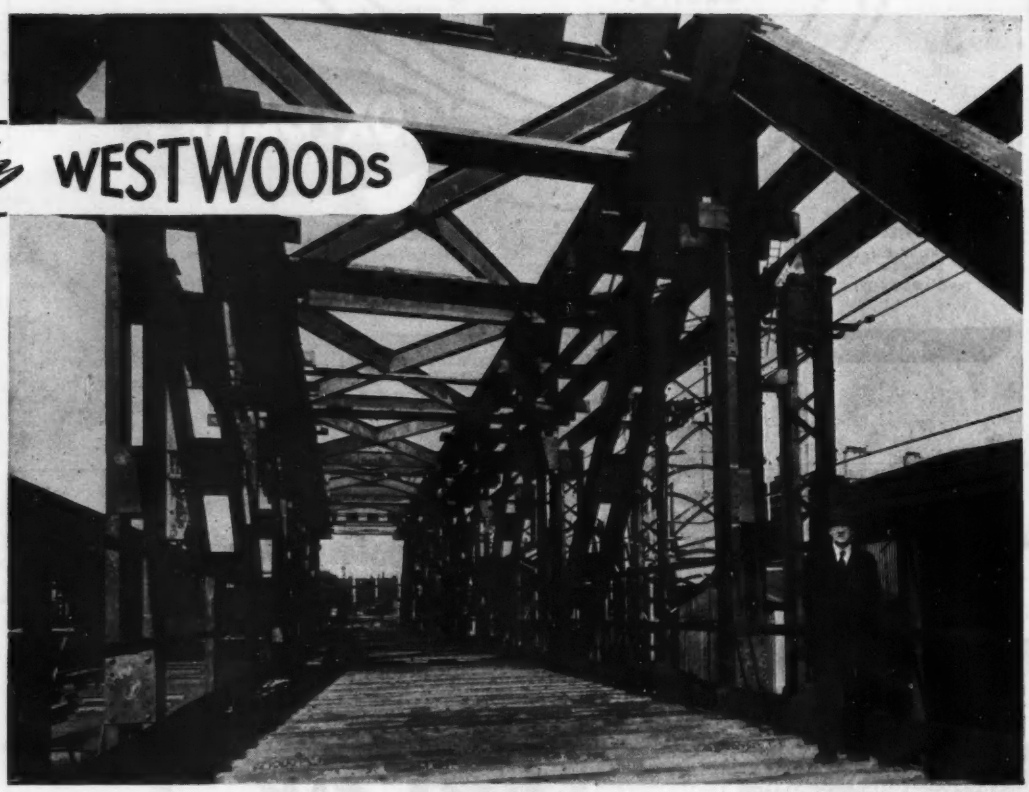

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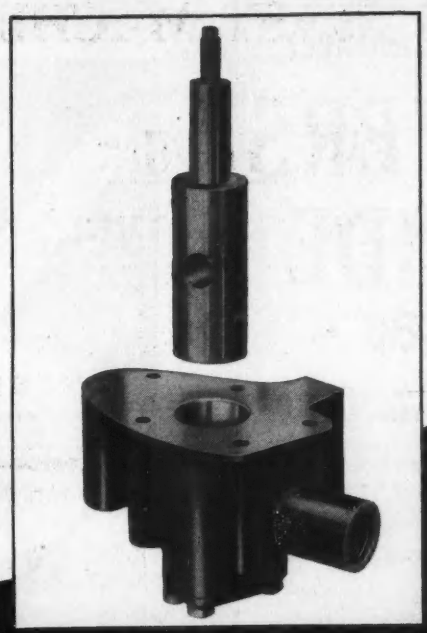

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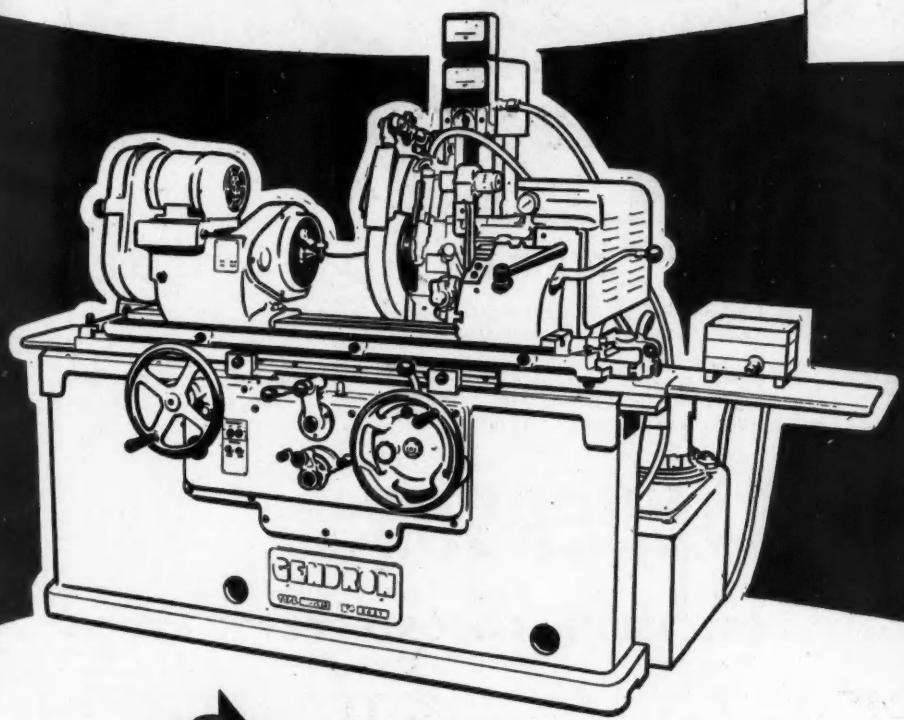

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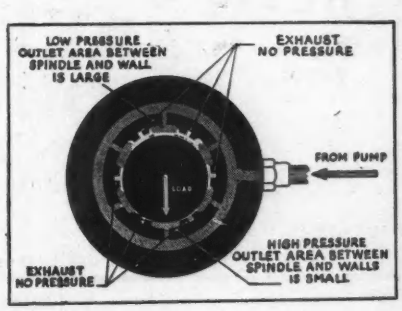
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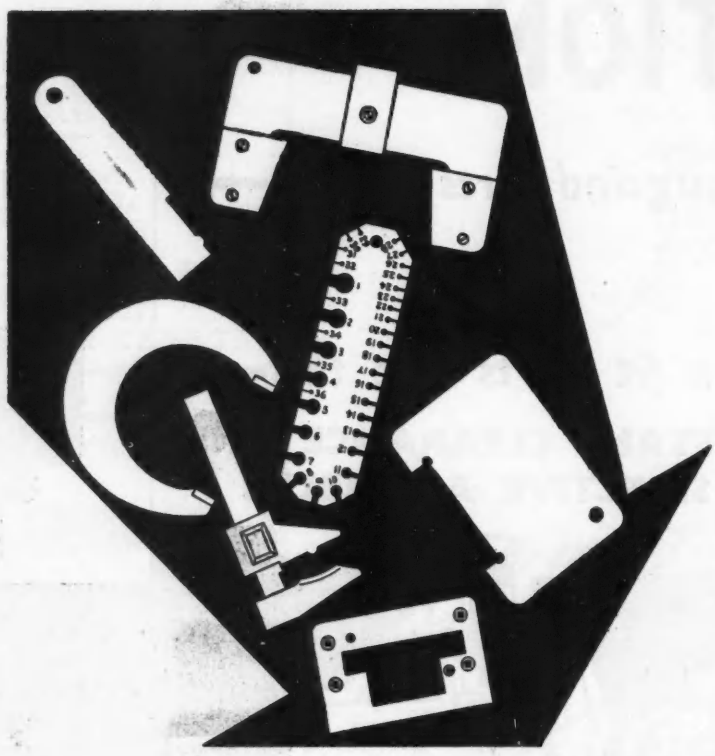

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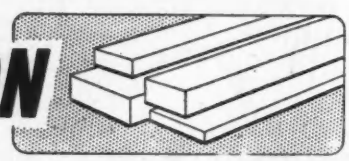

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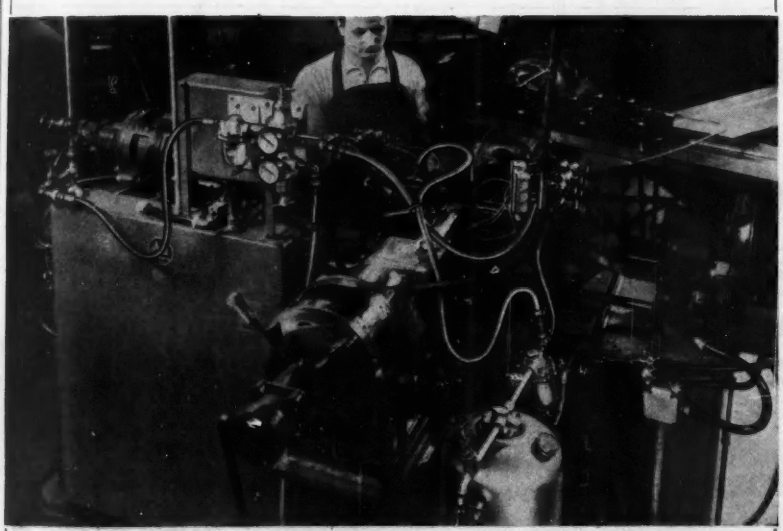

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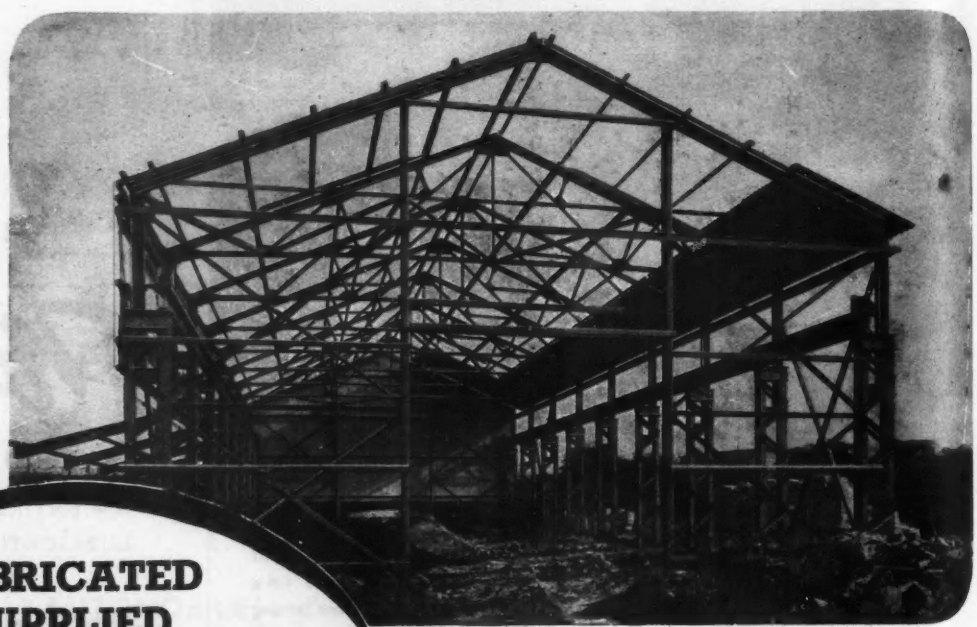

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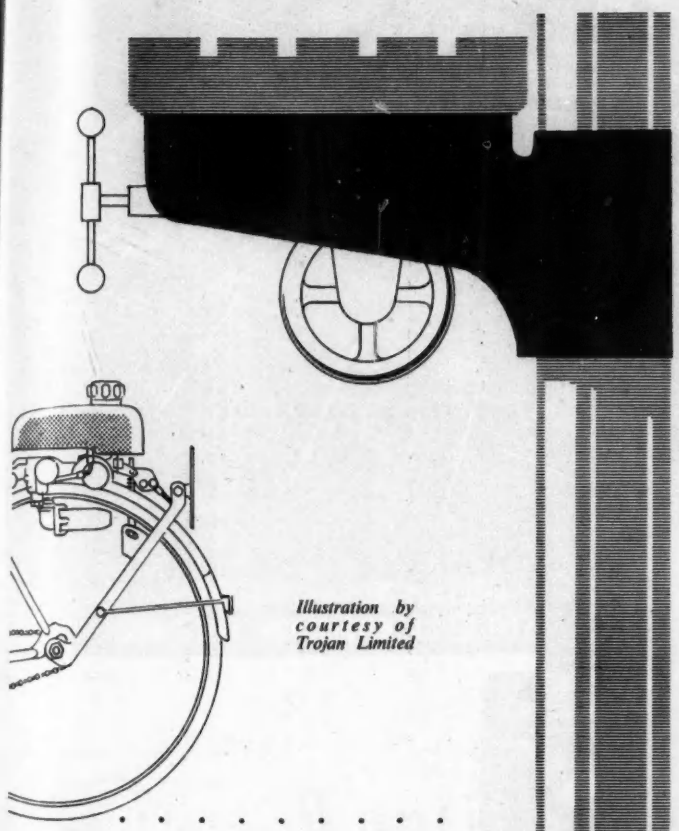

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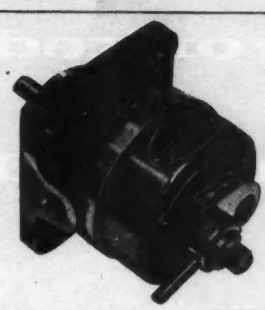

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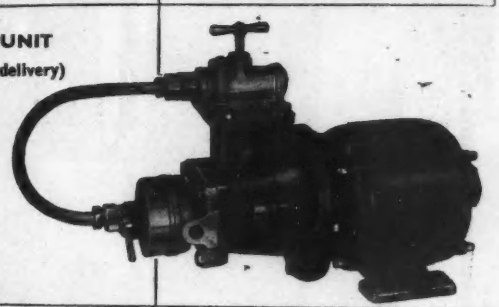

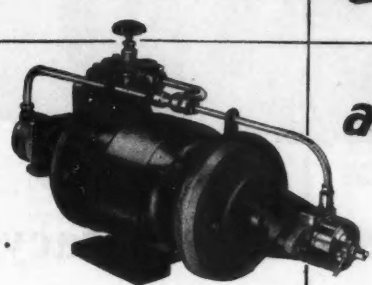

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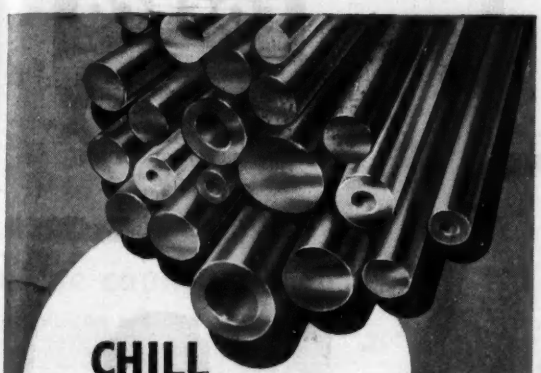

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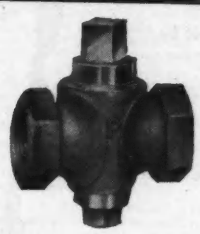

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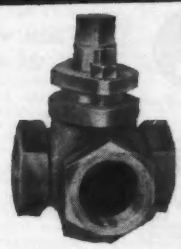

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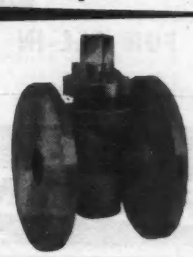

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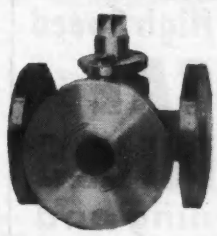

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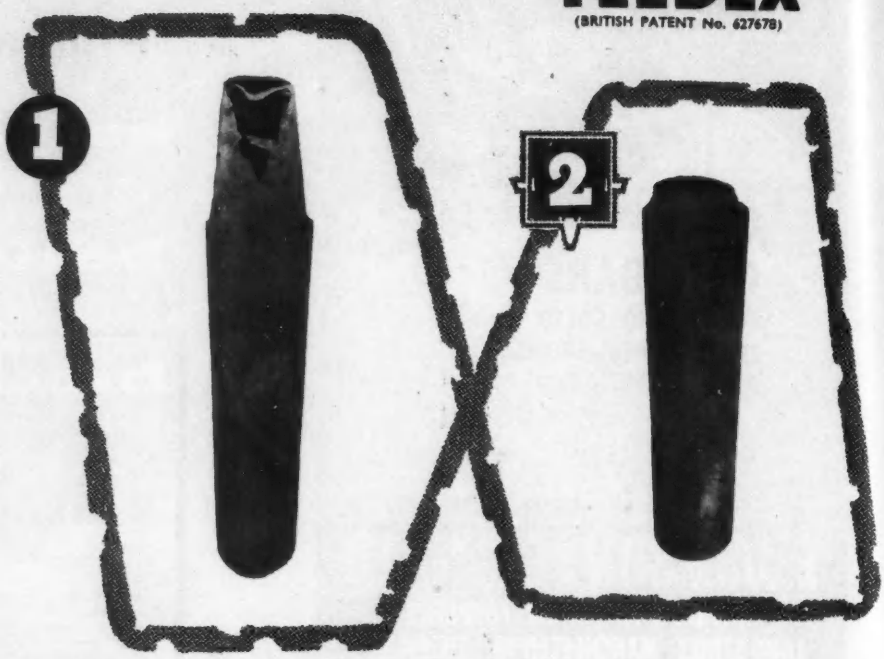

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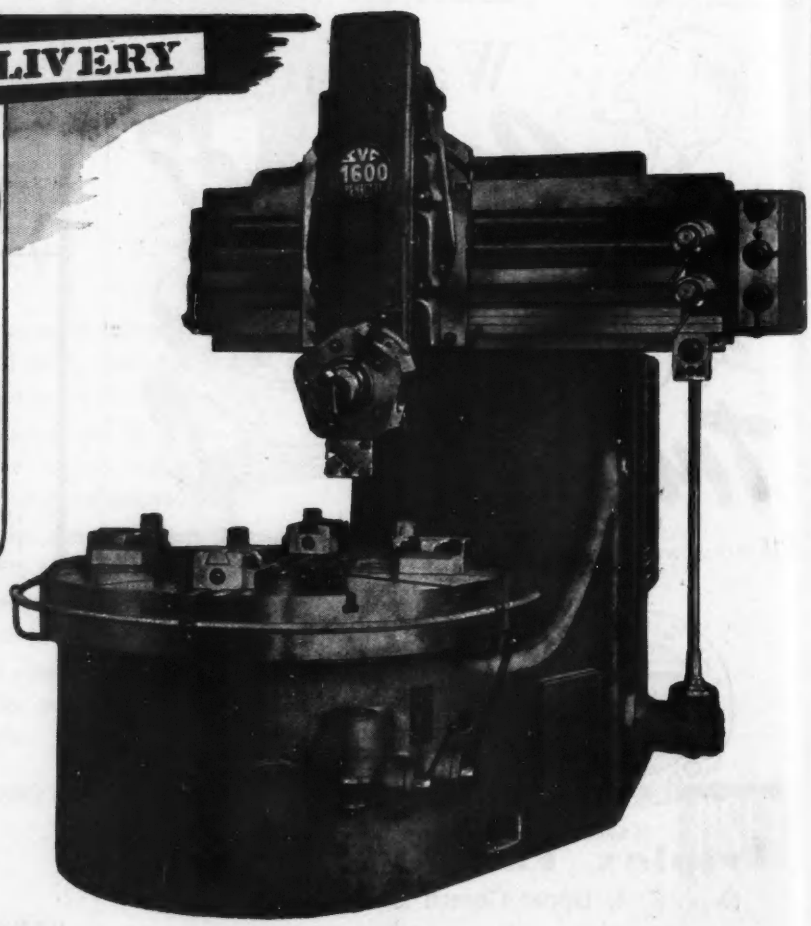

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New Size No. 11 "FARRATUBE" Economic Boiler, 18ft. over combustion chamber × 14ft. over tube-plates × 8ft. diam., W.P. 120 lb. sq. in., evap. 7000 lb. steam hr., 212 deg. F., or 5840 lb. at 60 deg. F.

Boiler by STOCKTON CHEMICAL ENGINEERS & RILEY BOILERS, 15ft. over tube-plates × 6ft. int. diam., evap. 4000 lb. hr. at 212 deg. F., W.P. 225 lb. sq. in.

Self-contained Boiler by DANKS, 11ft. over tube-plates × 6ft. diam., evap. 2500 lb. hr., W.P. 150 lb. sq. in., fitted "Rotamiser" oil burning equipment by Combustions, Ltd., Mowbrey controls, Weir feed pump, 600 g.p.hr., and steel chimney, 2ft. diam. × 55ft., with guys.

Treble Pass Super Economic Boiler by DANKS, 14ft. 9in. overall × 11ft. over tube-plates × 6ft. diam., W.P. 100 lb. sq. in., evap. 2500 lb. hr., single furnace with "Rotamiser" oil burning unit, induced draught fan, Weir feed pump and steel chimney, 40ft. × 24in. diam., in two lengths.

Self-contained Double Pass Boiler by RANKIN & Blackmore, 14ft. 6in. overall × 12ft. over tube-plates × 7ft. 3in. diam., evap. 4000 lb. hr., F. and A. 212 deg. F., pressure 250 lb. sq. in., single flue fitted Hodgkinson Low Ram stoker, steel chimney, 27in. diam.

New Size No. 6 "FARRATUBE" Economic Boiler. 13ft. 9in. over combustion chamber × 10ft. 6in, over tube-plates × 6ft. diam., W.P. 100 lb. sq. in., evap. 2840 lb. steam hr., 212 deg. F., or 2340 lb. hr. at 60 deg. F., immediate delivery.

DAVEY PAXMAN Treble Pass Ultranomic Boiler, 13ft. 9in. overall, 9ft. 3in. between tube-plates × 8ft. diam., W.P. 160 lb. sq. in., evap. 4000 lb. at 212 deg. F.

Single Pass Ultranomic Boiler by DAVEY PAXMAN, 17ft. overall × 12ft. 6in. over tube-plates × 6ft. 9in. diam., evap. 3500 lb., F. and A. 212 deg. F., pressure 150 lb. sq. in., single furnace fitted Clyde 10AH2 oil burning equipment, 20ft. chimney.

WATER-TUBE BOILERS

Size No. 9 FRASER & FRASER Water-tube Boiler, Evap. 3200 lb. hr. at 100 lb. sq. in., W.P. fitted with under-driven worm feed type stoker by Ivo. Eng., motorized 400/3/50, dimensions 12ft. 6in. high × 7ft. 3in. wide × 10ft. 6in. deep.

Two BABCOCK & WILCOX Boilers, W.I.F. Type, arranged as pair, heating surface 3580 sq. ft. each., evap. 12,500 lb. each, normal, up to 16,000 lb. forced, W.P. 170 lb. sq. in., superheater 396 sq. ft., heating surface, each has two horiz. steam drums 24ft. × 3ft. 6in. diam., with Babcock & Wilcox chain grate stokers if required.

Size No. 8 FRASER & FRASER Water-tube Boiler, evap. 2500 lb. hr. at 120 lb. sq. in. W.P., with oil-burning equipment by Urquhart, Ltd., also fuel storage tank for 2750 gal., boiler feed pump and 20ft. chimney.

LOCOMOTIVE TYPE BOILERS

Semi-portable Loco. Type Boiler by MARSHALL Sons & Co., overall length 13ft., incl. firebox 4ft., smokebox 30in., barrel 6ft. 3in. × 34in. diam., evap. 1500/1800 lb. hr. at W.P. 220 lb., fired by hand op., oil-burning equipment with two burners, with 200 gal. fuel tank and horiz. boiler feed pump.

ROBEY Loco. Type Boiler, Size 24, overall length 14ft. 5in. × 3ft. 7in. × 5ft. high, barrel 7ft. × 3ft. diam., total heating 279 sq. ft., evap. 1500 lb. at 60 deg. F., W.P. 120 lb.

ROBEY Loco. Type Boiler, 7ft. × 20in. diam., barrel mounted on steel chassis with road wheels.

Loco. Type Boiler by MARSHALL, overall length 12ft. 6in., including firebox 42in. long, barrel diam. 33in., evap. 1150 lb. at 60 deg. F., W.P. 150 lb. sq. in.

VERTICAL CROSS-TUBE BOILERS

Size	Evap., Lb.	W.P. Lb.
13ft. × 6ft. Clayton	1600	100
12ft. 6in. × 5ft. 6in. Farrar	1500	100
12ft. × 4ft. 3in. Grantham	1250	100
11ft. × 4ft. Garrett	900	100
10ft. × 4ft. 3in. Garrett	850	100
8ft. 6in. × 3ft. 6in. Dodman	590/710	100
7ft. 9in. × 3ft. 6in. Grantham	460	100
7ft. 6in. × 3ft. 6in. Grantham	450	80
7ft. 6in. × 3ft. 3in. Grantham	400	80
7ft. 6in. × 3ft. 3in. Coltman	450	100
7ft. 6in. × 3ft. 3in. Coltman	450	80
7ft. 6in. × 3ft. 3in. Clayton	440	100
7ft. 4in. × 3ft. Farrar	375	180
7ft. × 3ft. Farrar	360	100
7ft. × 3ft. Clayton	360	100

LATHES

DEAN SMITH & GRACE Straight Bed Lathe, 12in. centre height, admits 11ft. between centres, 16 spindle speeds, 11·4 to 256 r.p.m., enclosed gearbox, giving feeds 26–208 cuts per in., motorized 400/3/50.

BROADBENT 16in. Gap Bed Lathe, motorized 400/3/50, centre height 16in., between centres 8ft., S.S. and S.C., swing in gap 56in. diam. × 20in. in front of faceplate, hollow spindle bored 5¼in. diam., 24 spindle speeds, 5–300 r.p.m., 9 rates feed by quick change gearbox to sliding and surfacing motions, 32in. diam. faceplate.

DEAN, SMITH & GRACE, 8½in. × 4in. between centres, Gap Bed, arranged S.S. and S.C., motorized 400/3/50, swing in gap 27in. × 9in. in front of faceplate, hollow spindle bored 2in. diam., 18 spindle speeds, 14·9 to 480 r.p.m., tailstock bored No. 4 M.T.

CARDIFF 7in. × 34in. Gap Bed Lathe, S.S. and S.C., motorized 400/3/50, swing in gap 19¾in. × 5¾in., 18 spindle speeds, 27–757 r.p.m., hollow spindle bored 1¼in. diam.

HOLBROOK 6¼in. × 36in. B.C., Gap Bed Lathe, with inverted vee bed and AGH., motorised 400/3/50, spindle 1¼in. diam., 12 spindle speeds, 15–400 r.p.m., Norton type feedbox.

VOLMAN Gap Vee Bed S.S. and S.C. Lathe, 7½in. centre height, admits 40in. between centres, hollow mandrel 1¼in., swing in gap 20in. × 5¼in., 6 spindle speeds, 48–480 r.p.m.

CHURCHILL REDMAN Model 7NM, all-geared head, Gap Flat Bed, motorized 400/3/50, 7in. centre height, 30in. between centres, swing in gap 27in. × 9in., 16 spindle speeds, 13–440 r.p.m., quick change feedbox.

CRAVEN 42½in. × 65ft. B.C., S.S. and S.C. Lathe, swing 71in. diam. over saddles, 84in. diam., geared 4-jaw independent chuck, 6 spindle speeds, 1·27 to 30 r.p.m., motorized 220V., D.C.

WALDRICH Heavy Duty S.S. and S.C. Lathe, centre height 27in., distances B.C. 21in., swing over bed 54in. diam., swing over saddle 43in. diam., 16 spindle speeds, 1·12 to 83 r.p.m., 16 rates sliding feed, 0·0083in. to 2402in. per rev. faceplate, 16 surfacing feeds, 0·0019in. to 0·0568in., motorized 400/3/50, includes two stationary steady rests and and change wheels for screw cutting.

PRENTICE 20in. Straight Bed Lathe, motorized 400/3/50, S.S. and S.C. centre height 11in., bed 8ft., admits 38in. between centres, Norton type quick change gearbox.

CRAVEN 18¼in. × 40ft. Straight Bed Lathe, swing over bed 42in. diam., swing over cross slides 28in. diam., gear changes and variable speeds motor give almost stepless range, speeds 1·9 to 168 r.p.m., S.S. and S.C., with geared taper turning to each of 2 saddles, 12 rates surfacing feeds, 0·005in. to 0·25in. per rev., 12 rates sliding feed, 0·01in. to 0·5in. pre rev., main motor 40 h.p., 500 volts D.C

LANG 15½in. × 28ft. Straight Bed Lathe, motorized 480 volts D.C., twin saddles and 30in. geared chuck, swing over bed 32in. diam., hollow spindle, admits 3in. diam., tailstock bored No. 6 M.T., 24 spindle speeds, 2–200 r.p.m., Norton type feedbox gives 28 selections sliding and surfacing feeds.

Two SWIFT 15in. × 22ft. Straight Bed Lathes, swing over cross slides 22in. diam., 18 spindle speeds, 1·5 to 94 r.p.m., quick change gearbox, 9 rates of feed, 8·5–510 cuts per in., hollow spindle admits 1¾in. diam., tailstock bored No. 6 M.T., motorized 400/3/50.

CRAVEN 14in. × 25ft. Flat Bed Lathe, S.S. and S.C and geared taper turning, swing over bed 30in. diam., hollow spindle bored 2¼in. diam., tailstock bored No. 5 M.T., motorized 400/3/50.

LODGE & SHIPLEY 18in. Straight Vee Bed Lathe, all-geared head, S.S. and S.C., 9¼in. centre height, admits 8ft. between centres, motorized 400/3/50, 9 spindle speeds, 32–354 r.p.m., quick change gearbox, 66 changes, pitches 1–64 t.p.i.

BINNS & BERRY 8½in. × 13ft. between centres, Straight Bed Centre Lathe, S.S. and S.C., motorized 400/3/50, hollow spindle admits 2in. diam., 9 spindle speeds, 15–325 r.p.m., quick change gearbox, tailstock bored No. 4 M.T.

HOLBROOK 6½in. × 30in. Centre Lathe Model, N.88, motorized 400/3/50, all-geared head, 12 spindle speeds, 15–400 r.p.m., hollow spindle 1¼in. diam., Norton type gearbox, giving 36 feed selections, 8–420 c.p.i.

LANG 14in. swing Surfacing and Boring Lathe, arranged for sliding and surfacing, motorized 400/3/50, 12 spindle speeds, 20·6 to 908 r.p.m., 6 sliding feeds, 12–144 c.p.i., hollow spindle 1¾in.

POWER PRESSES

150-ton TOLEDO 57, Straight Side, Single Crank, Double Geared Press, belt-driven, between uprights 24in., table size 23in. × 28½in.

BLISS 6/60 Straight Side, Double Crank, Geared Press, motorized 400/3/50, capacity 150 tons, stroke 6in., manual ram adjust. 3½in., fitted Marquette Air Cushion equipment, between uprights 60½in., table size 34in. × 59in., loose bolster 5in. thick, strokes per min. 19.

DANIEL SMITH 150-ton Straight Sided, Geared Power Press, No. 9, stroke 12in., max. daylight under ram 22in., bed to guides 18in., bed area 23in., between frames × 24½in., hole in bed 7½in. diam., motorized 400/3/50.

DAMIEL SMITH Straight Side Geared Power Press, capacity 100 tons, stroke 16in., max. daylight under ram 22in., bed to guides 17½in., motorized 400/3/50

BLISS 20-ton Open Front, Inclinable Power Press, motorized 400/3/50, fixed stroke 2in., opening through back 9in., bed area 22in. × 14in., with 12in. × 9in. opening.

TAYLOR & CHALLEN G.D.P., 3-geared, Double Action Drawing Press, motorized 400/3/50, stroke 8in., blank stroke 4in., table size 20in. × 15½in., between uprights 20in.

HORDERN & MASON No. 10, Double Action, Geared Drawing Press, motorized 400/3/50, punch stroke 6in., blank stroke 3in., table size 15in. × 18in., between uprights 16½in.

HORDERN & MASON No. 12, Double Action Geared Drawing Press, motorized 400/3/50, punch stroke 8in., blank stroke 4in., table size 18in. × 21in., with 10in. hole in centre, between uprights 19in.

Six BLISS No. 19 Open Back Inclinable Presses, motorized 400/3/50.

250-ton TOLEDO, Model 99, Straight Side, Double Crank Geared Power Press, tie-rod constr., 4in fixed stroke, ram adjustment 6in., bolster 48in. × 94in. × 4½in., ram facing 37in. × 90in., pulley drive.

TURBO-ALTERNATOR SETS

3750-kW. METROPOLITAN VICKERS Condensing Geared Turbo Set, with boiler 200 p.s.i., 550 deg. F., 6600 volts, 3 phase, 50 cycles, surface condenser, ancillaries, switchgear, boiler, Stirling type Tri-drum water-tube, 200/210 p.s.i.

2750/3000-kW. FRASER & CHALMERS/G.E.C. Condensing Geared Set, 150 p.s.i., 460 deg. F., 6600 or 3300 volts, 3 phase, 50 cycles, surface condenser, ancillaries and switchgear.

600-kW. WEIR/E.E.C. Pass-out 150/190 p.s.i., 80 deg. F. superheat, back pressure 15 p.s.i., alternator 400/3/50.

DIESEL-ALTERNATOR SETS

600-kVA. BRITISH POLAR/A.S.E.A., engine vertical, 5-cylinder, 2-stroke, air start, 250 r.p.m. alternator 440/3/50.

Quantity 330-kVA. PAXMAN/B.T.-H. or CROMPTON PARKINSON, engine 12 cylinder, 12RPrl, electric start, 1000 r.p.m., alternator 440/3/50.

250-kVA. DEUTZ-SIEMENS SCHUCKERT, engine 290 h.p., vertical, 7-cylinder, 4-stroke, air start, 500 r.p.m., alternator 6300/3/50.

Quantity of MIRRLEES, BICKERTON & DAY vertical, 4-stroke, air start, diesel-driven Alternator Sets, 400/440/3/50, as follows :—

Qty.	KVA.	Type	Speed	Alternator
1	75	U.A.3	600	L.D.C.
1	94	U.A.3	600	Met. Vick.
1	100	U.A.4	600	G.E.C.
1	147	ULA.5	500	L.D.C.
2	152·5	ULA.5	500	Met. Vick.
1	234	ULA.8	500	Met. Vick

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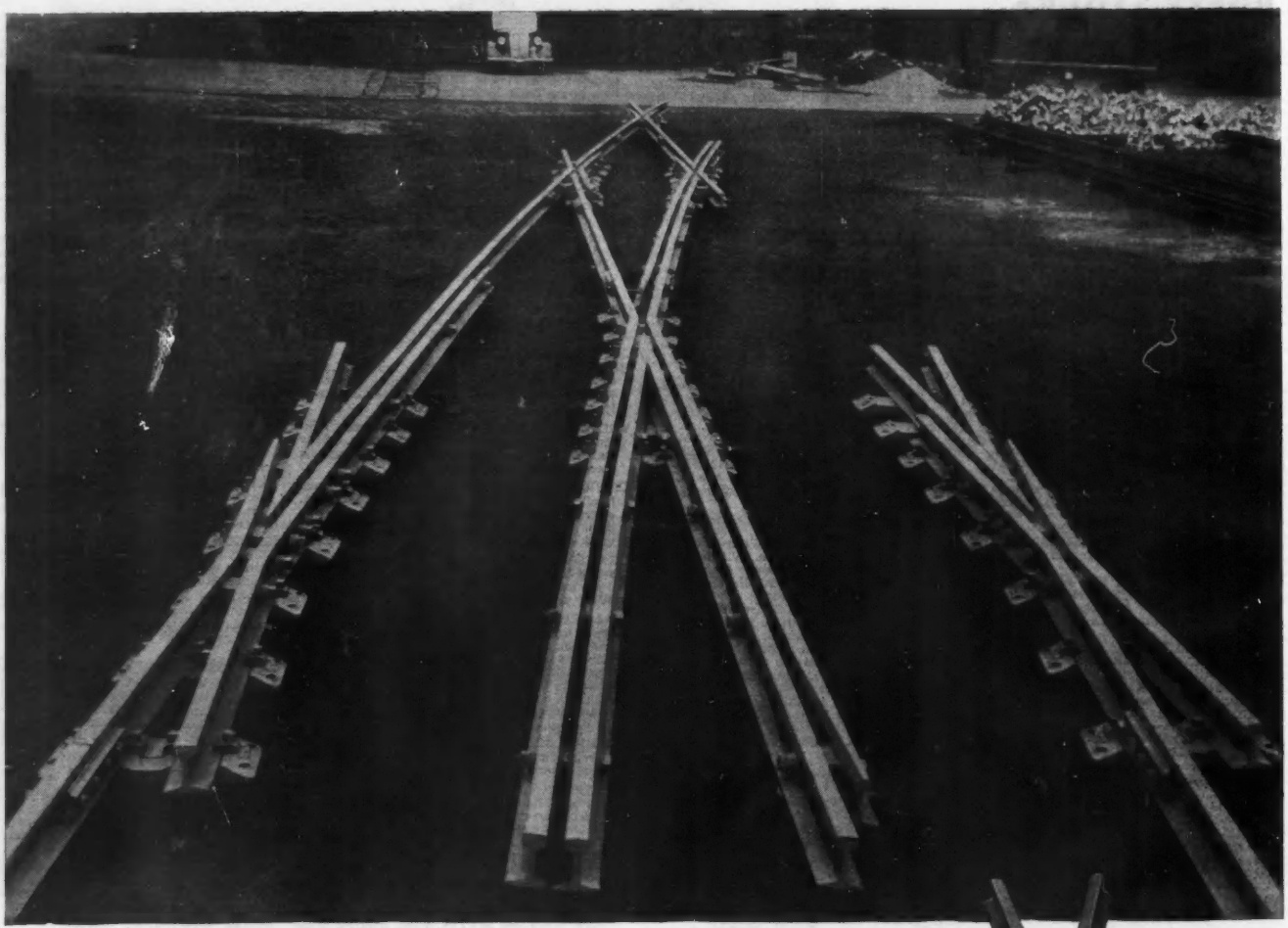
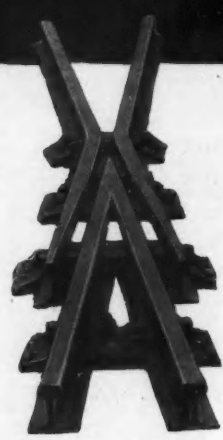


This photograph shows a double junction supplied to the Southern Region of British Railways. Because of the very heavy traffic running over it, the rails of which it is built up were rolled in 11/14% IMPERIAL high manganese steel to suit British Railways new 109 lb. per yard F.B. Section. This rail was rolled recently, for the first time in high manganese steel, at the Workington branch of The United Steel Companies in conjunction with Edgar Allen & Co., Limited. The switches are of the undercut and chamfered design to give strength to the switch toes. Crossings are of standard angles, and the layout was designed by British Railways to give easement curves from the switches through the layout.

Before despatch from Edgar Allen & Co., Limited, the junction was assembled in correct alignment, with British Railways standard chairs and fittings to ensure that the job fitted on site.



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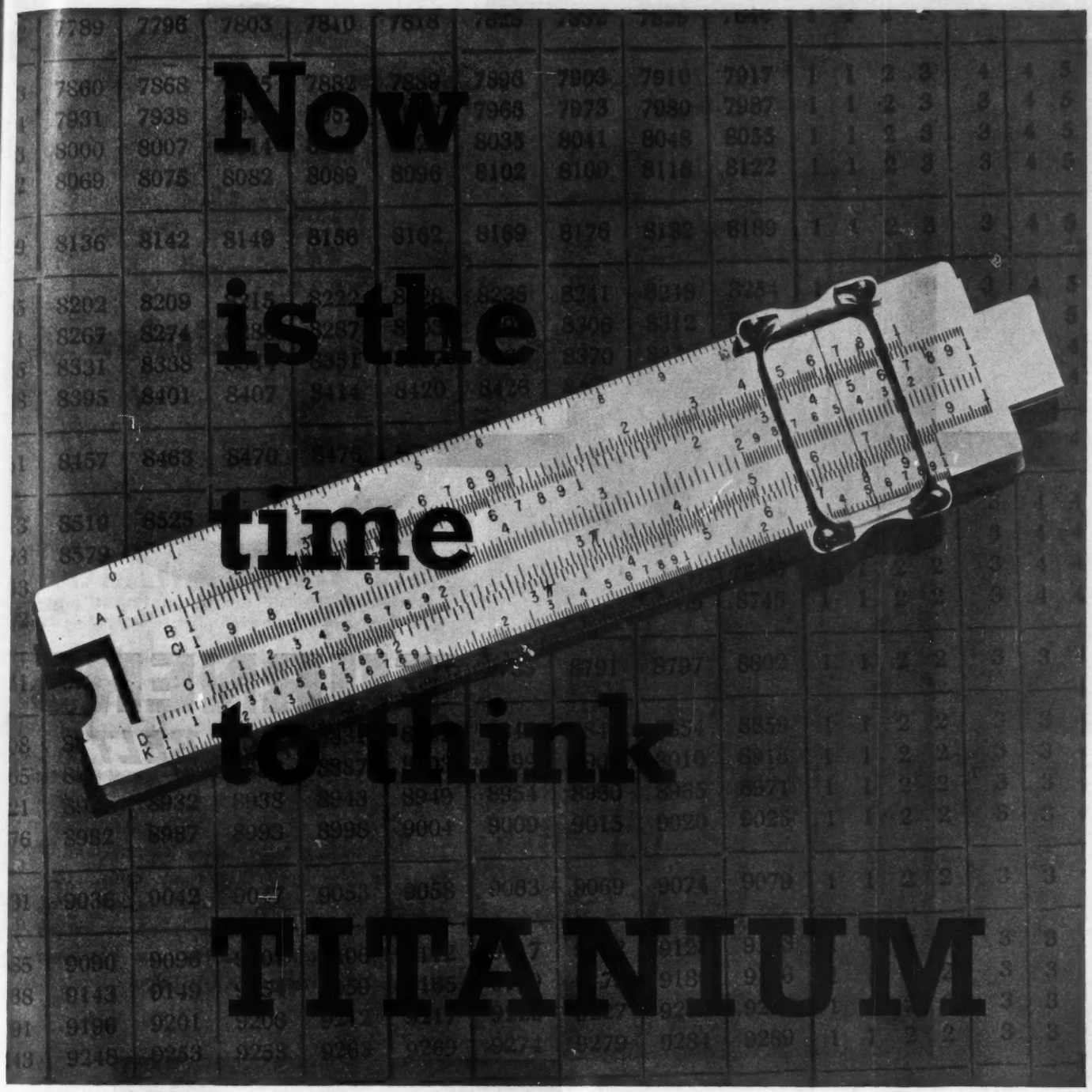

TALKING POINTS NO. 2 . . . Titanium and the "Temperature Barrier"

In spite of the high melting point of titanium (about 1700°C), the strength characteristics of the commercially pure metal are lower than might be expected at temperatures above 300°C.

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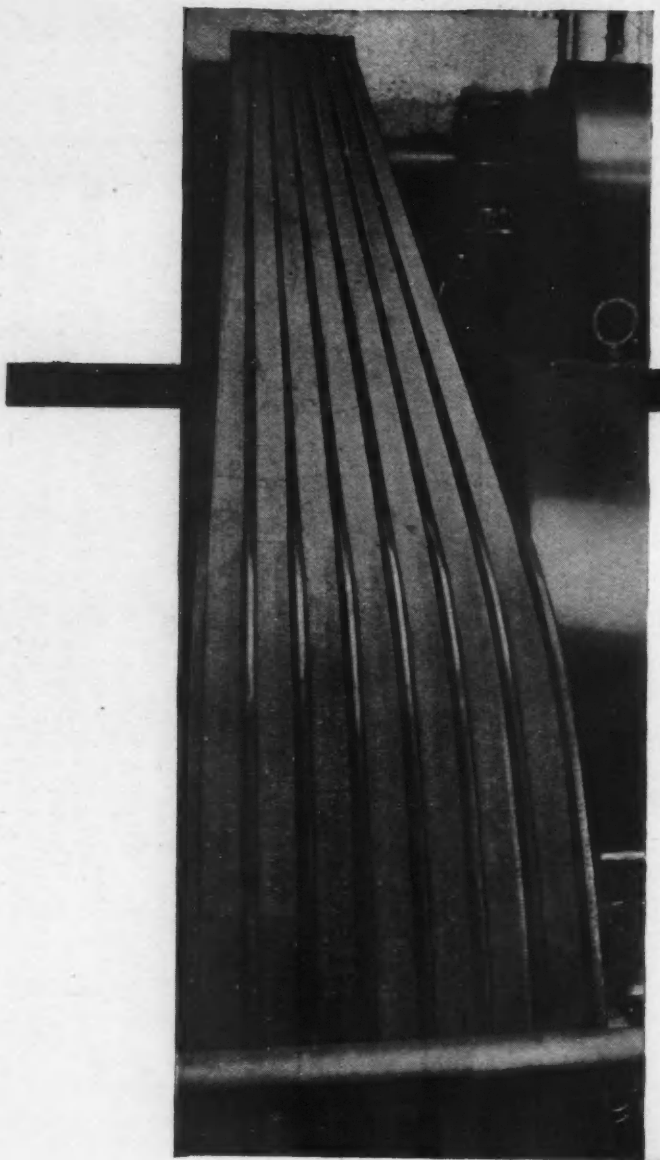

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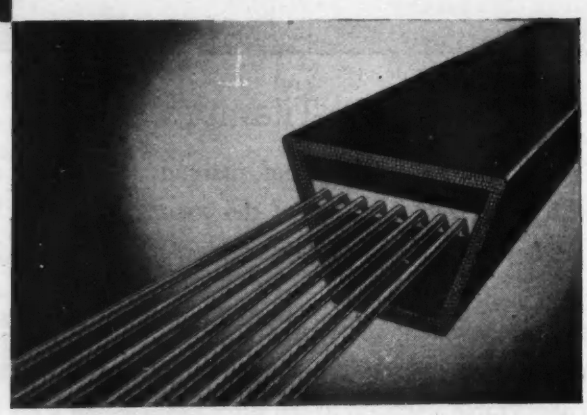

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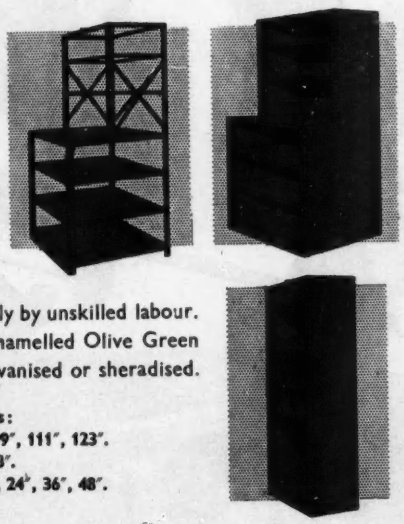

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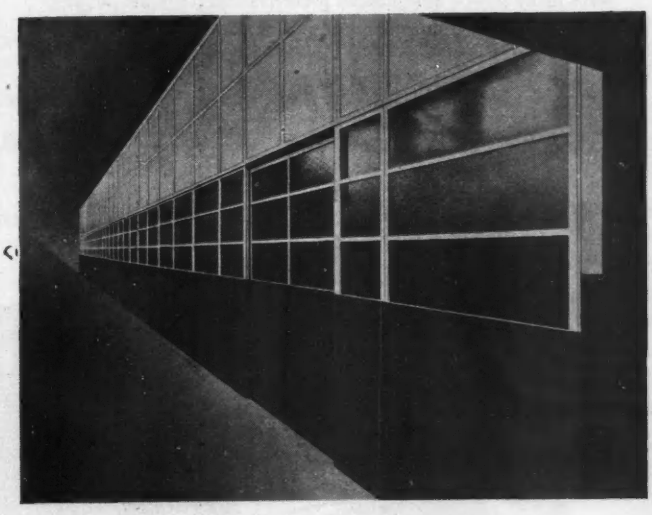

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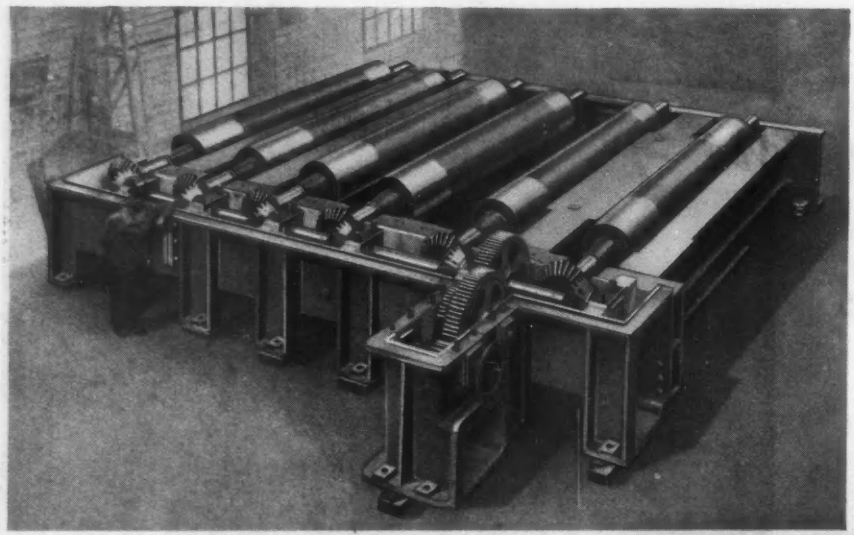

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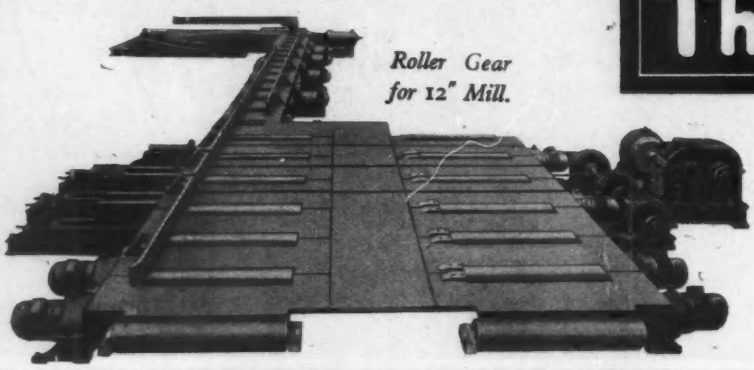

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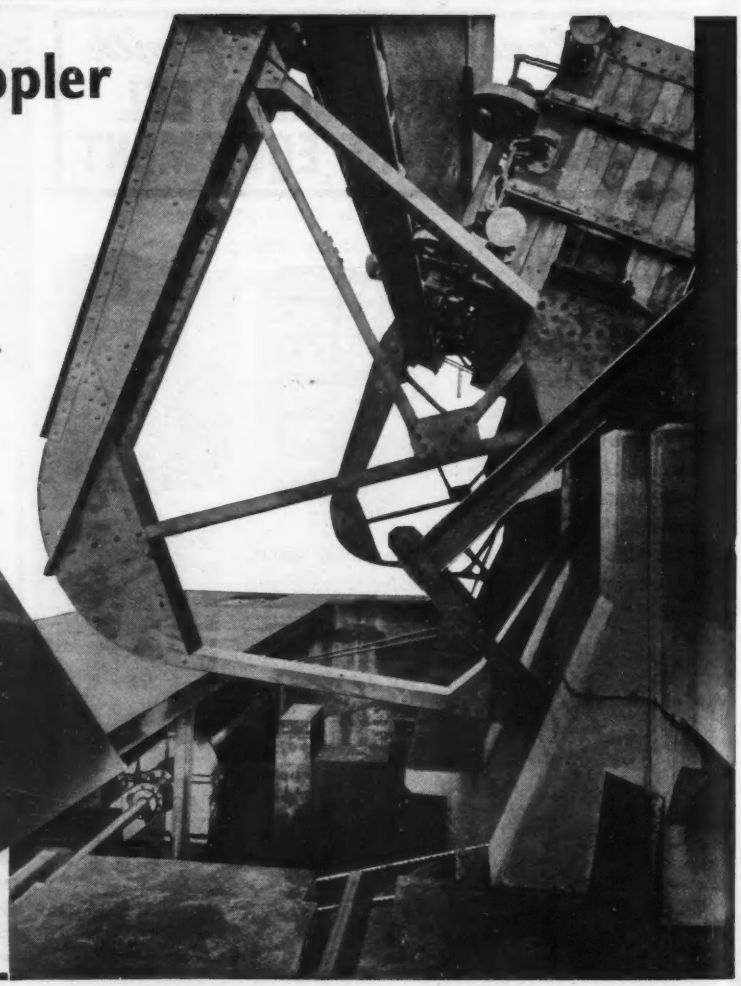

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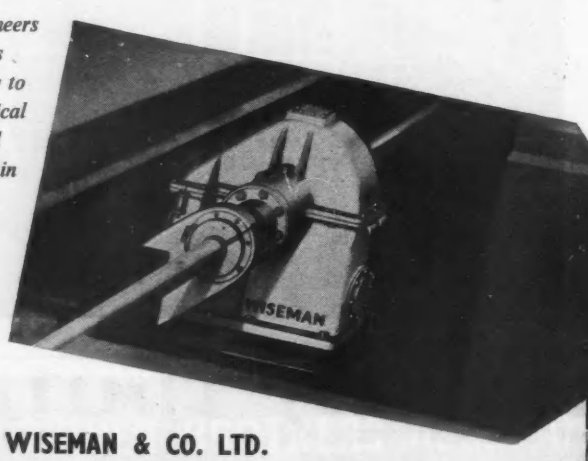

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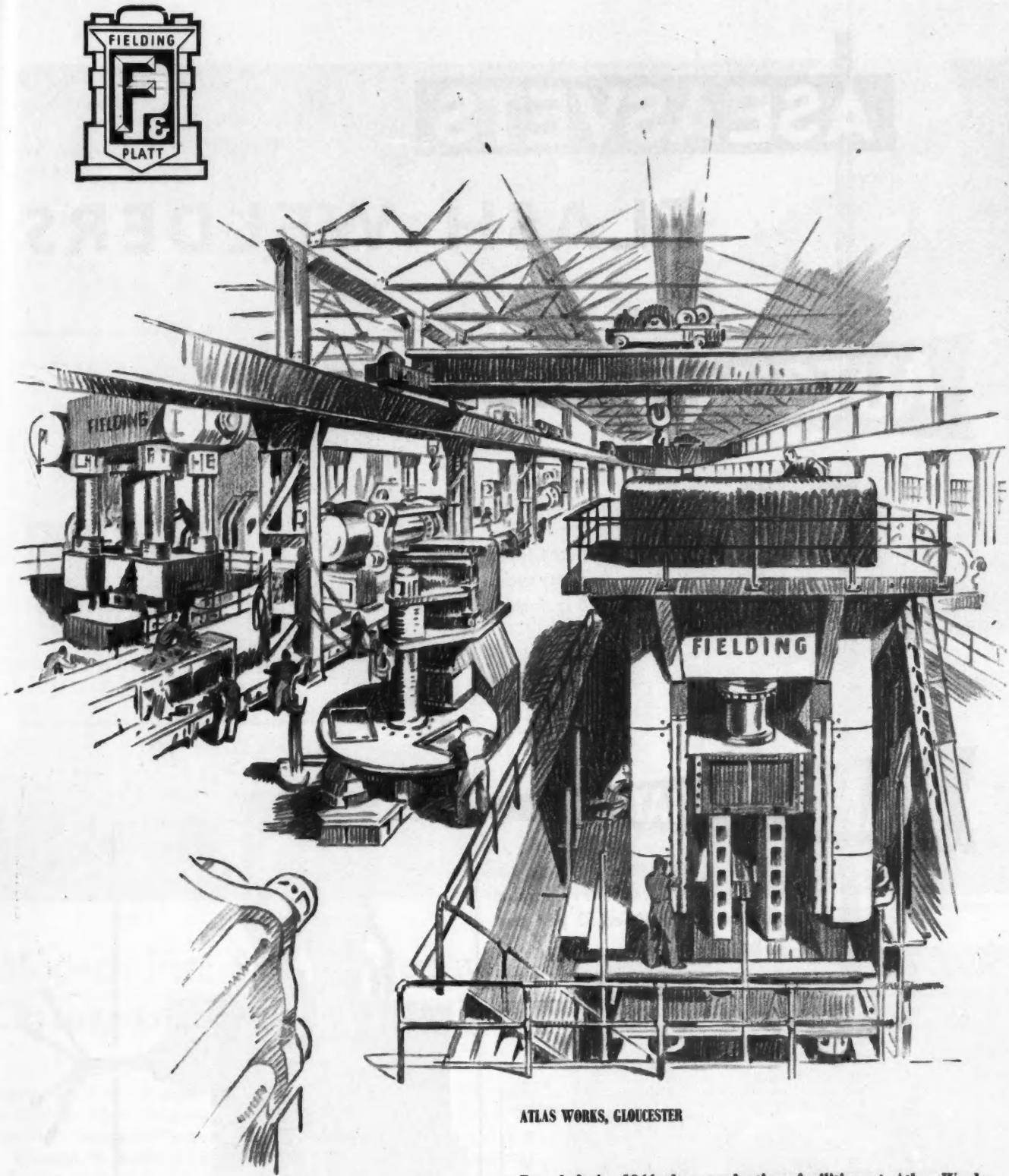

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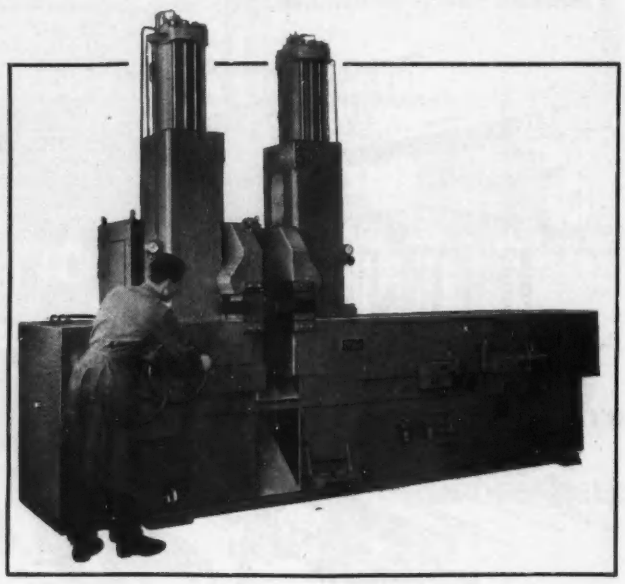
FLASH WELDERS

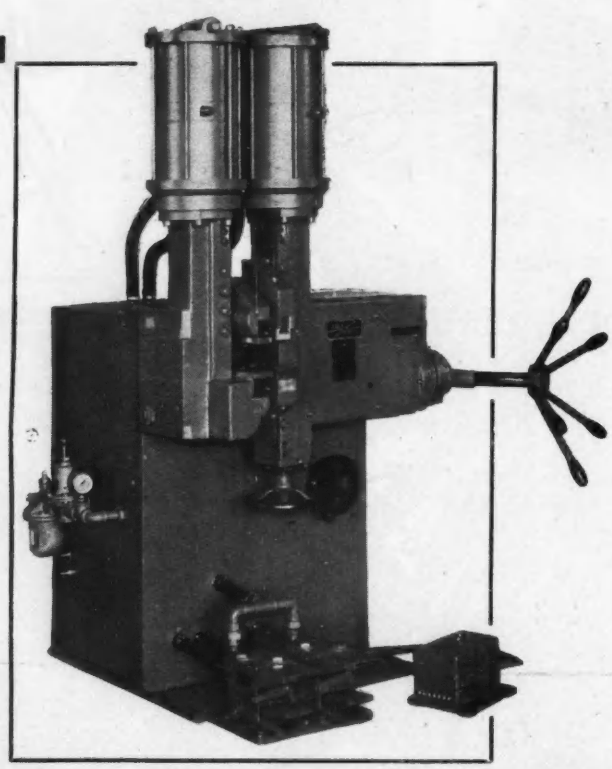
AUTOMATIC

Type SVU, size 9 automatic flash welder with hydraulic clamping. Clamping pressure 40 tons, upsetting pressure 27 tons. Rated input 2x250 kVA at 50 per cent duty cycle. Max. welding section 24·8 sq. inches.



HAND-OPERATED

Type SVU 424 hand-operated flash-welding machine with air-operated clamping; 25 kVA at 50 per cent duty cycle.



General Specification for type SVU Automatic Flash Welding Machines

Size	Rated input kVA 50 per cent	Max. clamping pressure tons	Max. upsetting pressure tons	Max. welding section sq. inches carbon steel Tensile strength of weld		Weight (including apparatus) tons
				85 per cent.	100 per cent.	
4	35	3	2	2·4	1·7	1·3
5	60	6	4	4·8	3·4	2·26
6	80	10	7	8·5	5·4	3·25
7	150	17·75	12	12·4	9·3	5·25
	250					5·4
8	350	26·5	17·75	17·8	13·9	8·9
	2×250					9·7
9	2×250	39	26·5	24·8	20·9	13·8
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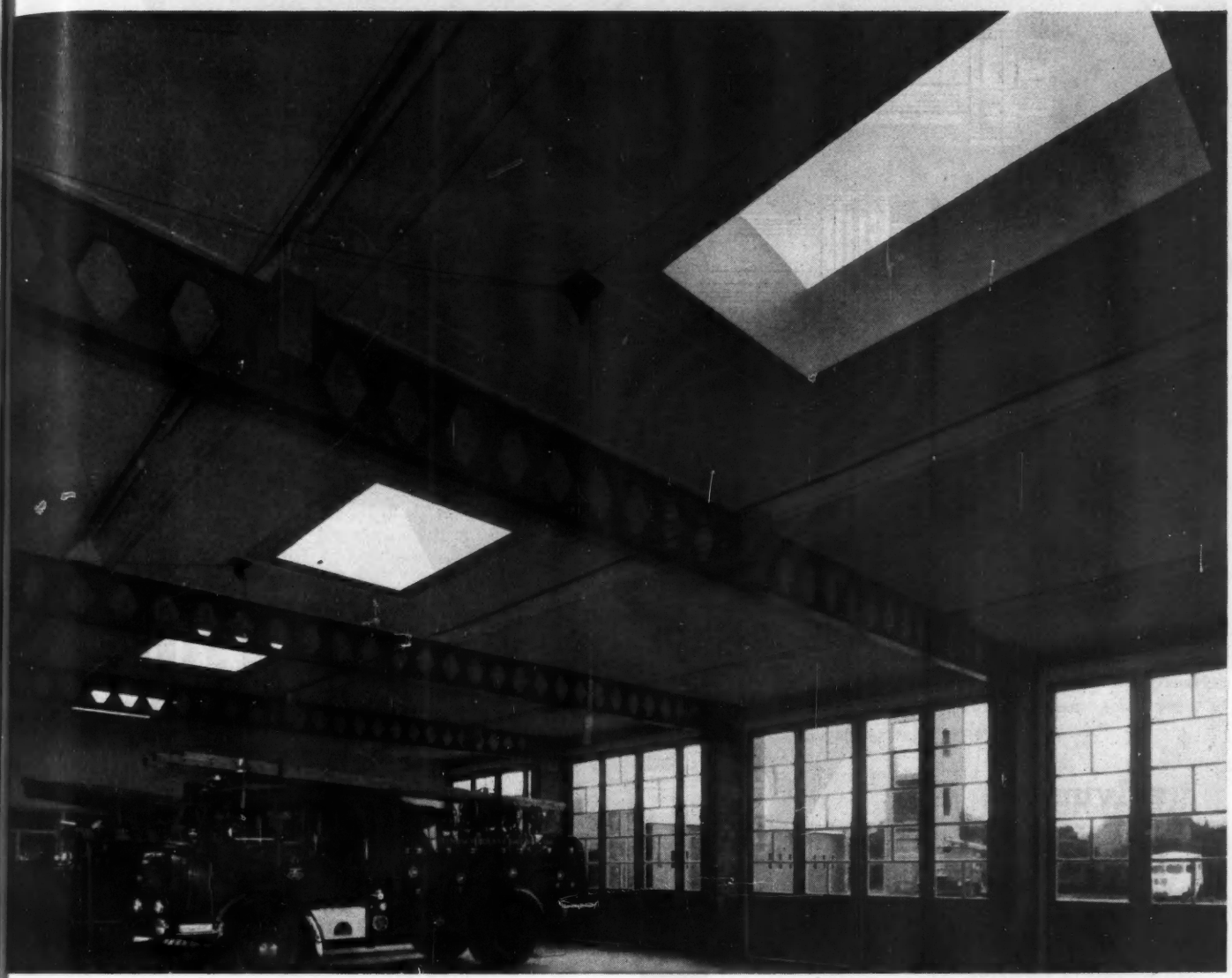

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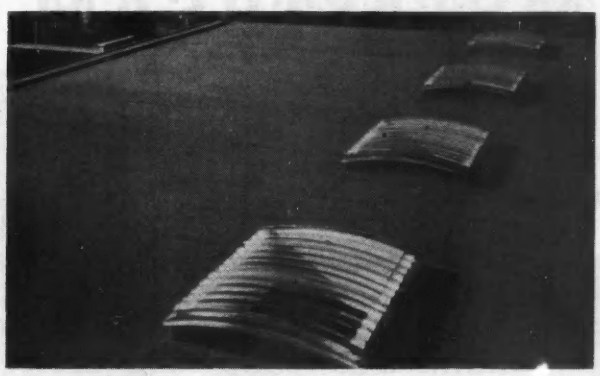

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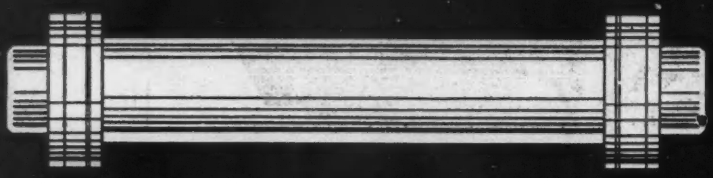
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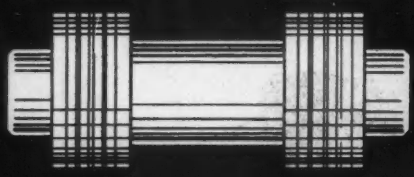
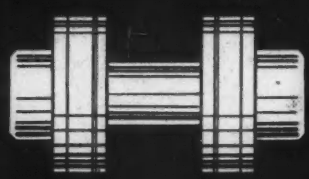

type M spacer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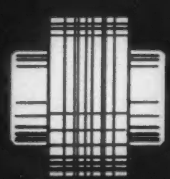
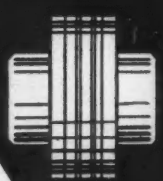

type M non-spacer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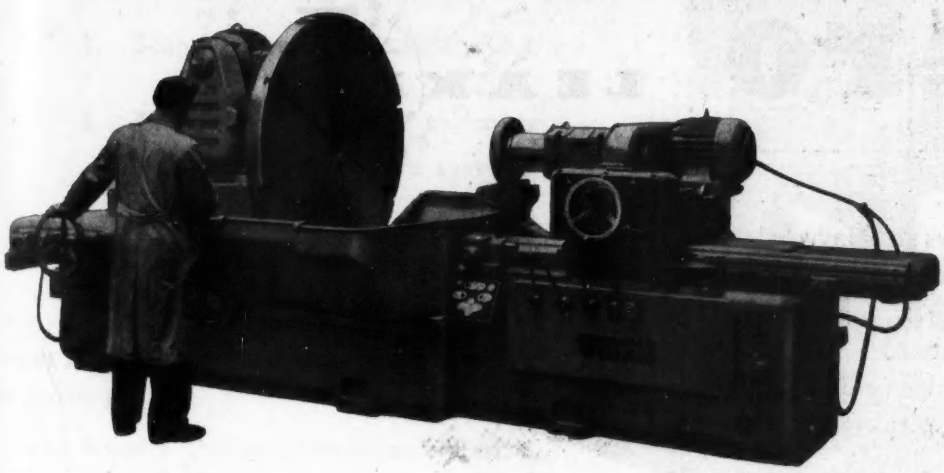

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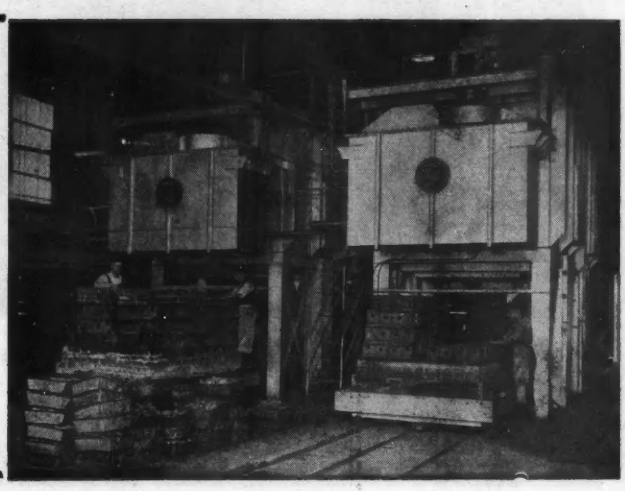

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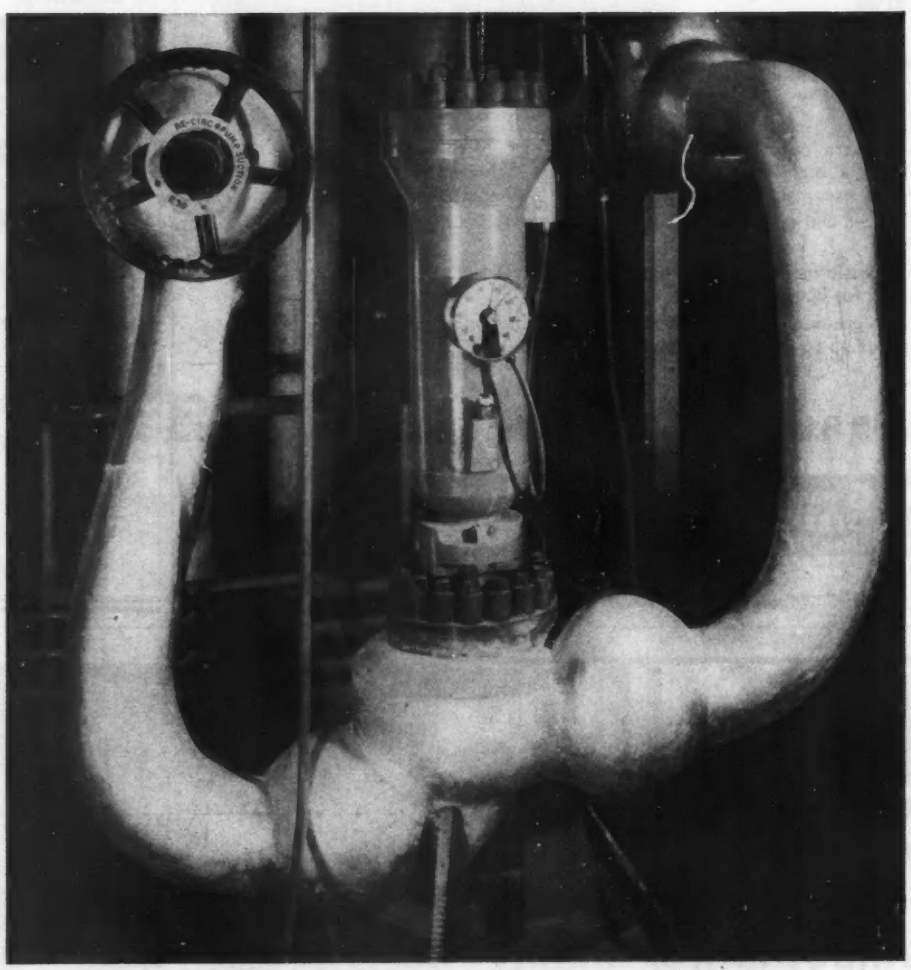

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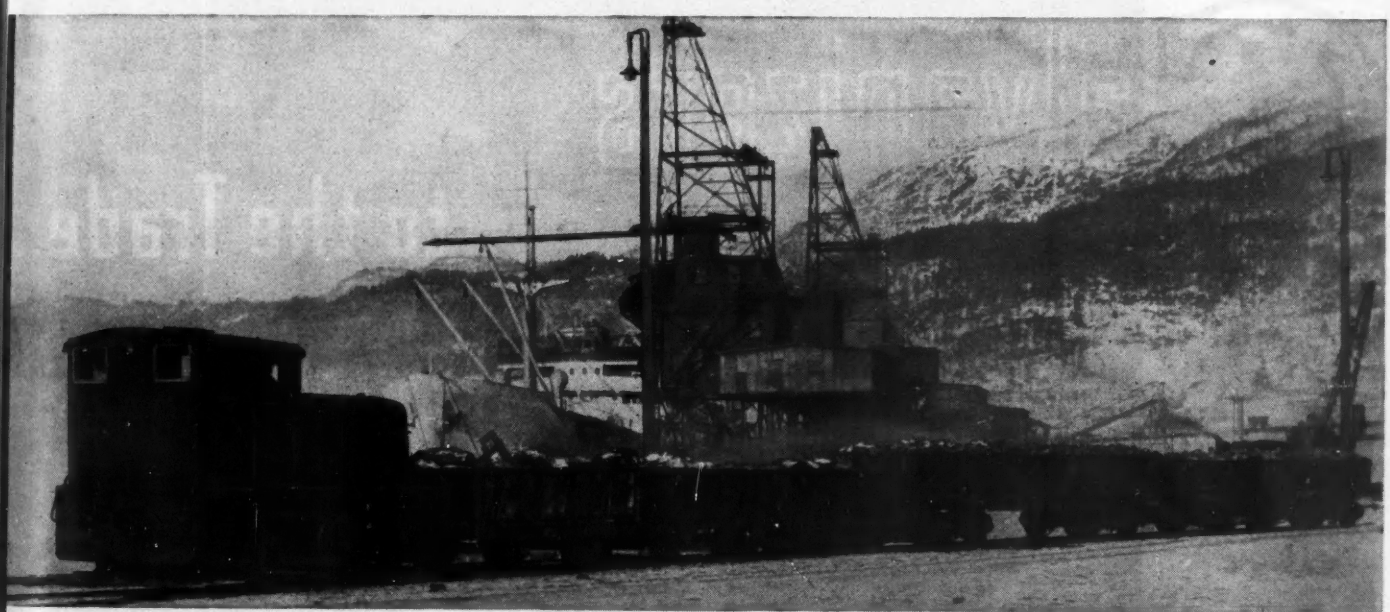

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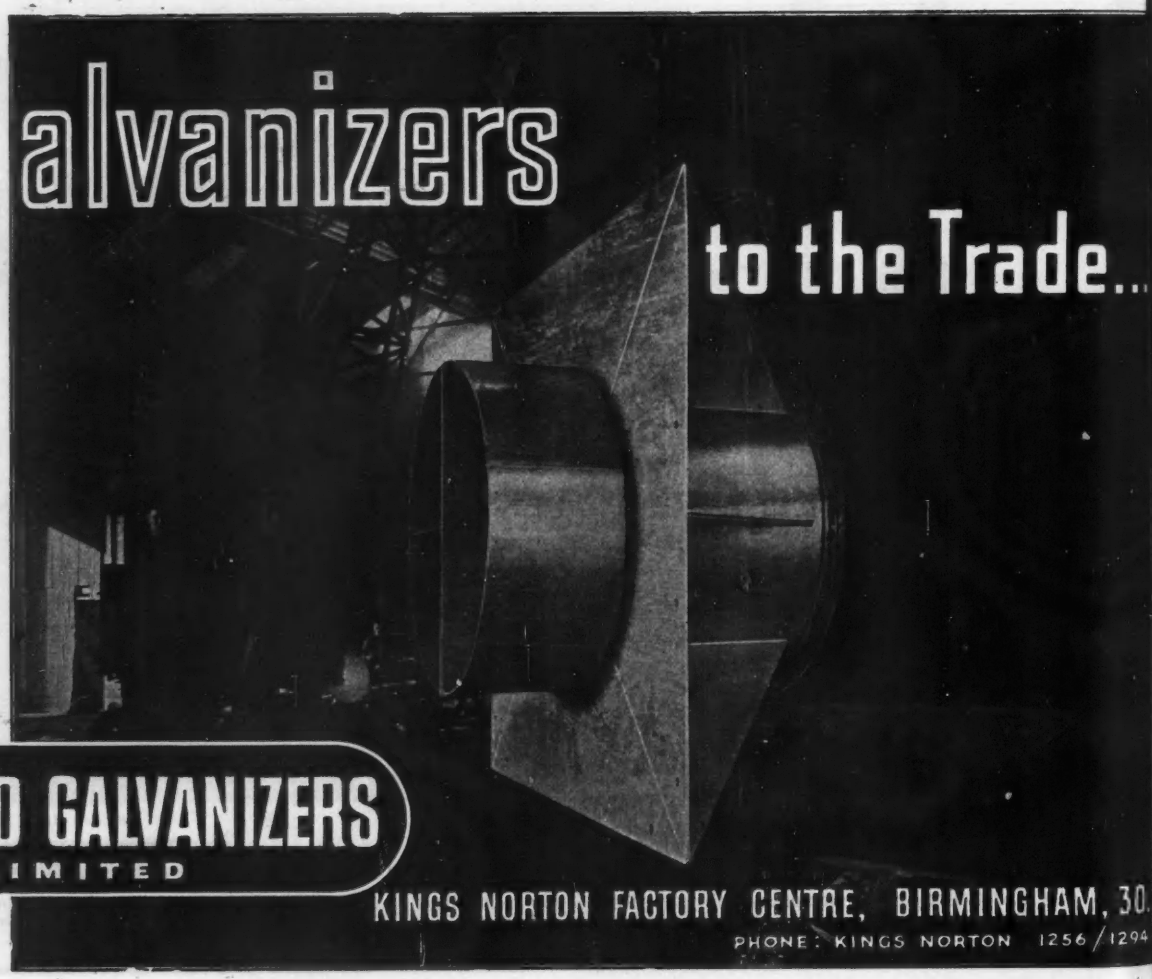

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INDEX TO ADVERTISERS

PAGE

AB Atlas Copco/Sweden 30–31–32–33
A.P.V. Co., Ltd. 108
Abbey Panel & Sheet Metal Co., Ltd. 93
Abix (Metal Industries), Ltd. 153
Acheson Colloids, Ltd. 123
Adams, C., & Co., Ltd. 123
Air Control Installations, Ltd. 112
Airesco Products, Ltd. 122
Alexander, G. H., Machinery, Ltd. 138
Allday, W., & Co., Ltd. 108
Alldays & Onions, Ltd. 92
Allen, E., & Co., Ltd. 150
Allott Bros. & Leigh, Ltd. 135
Aluminium Wire & Cable Co., Ltd. 78
Ames Crosta Mills & Co., Ltd. 74
Anderton Springs, Ltd. 101
Angus, G., & Co., Ltd. 64
Armstrong Patents Co., Ltd. 74
Armstrong Stevens & Son, Ltd. 56
Ates Electric, Ltd. 156
Asquith, W., Ltd. 77
Audley Engineering Co., Ltd. 50
Auto Aero, Ltd. 125
Automatic Pressings, Ltd. 92

B.A. Holland Engineering Co., Ltd. 18
B.R.C. Engineering Co., Ltd. 83
Burimar, Ltd. 17
Bedford, J., & Sons, Ltd. 125
Beecham Buildings, Ltd. 110
Bell's Asbestos & Engineering, Ltd. Cover i
Birmingham & Blackburn Construction Co., Ltd. 70
Blakeborough, J., & Sons, Ltd. 134
Booth, J., & Bros. 128
Brett's Patent Lifter Co., Ltd. 122
British Aero Components, Ltd. 98
British Columbia Lumber Manufacturers' Association. 116
British Electrical Repairs, Ltd. 22
British Ermeto Corporation, Ltd. 103
British Federal Welder & Machine Co., Ltd. 34
British Geon, Ltd. 53
British Paints, Ltd. 24
British Railways 37
British Steel Founders' Association. 146
British Thermostat Co., Ltd. 87
British Thomson-Houston Co., Ltd. 11
Broadbent, R., & Son, Ltd. 101
Bronx Engineering Co., Ltd. 21–108
Broom & Wade, Ltd. 47

PAGE

Brown, E. G., & Co., Ltd. 142
Brownlie & Murray, Ltd. 122
Bryans Aeroquipment, Ltd. 161
Budworth, D., Ltd. 22
Butcher, H., & Co. 2
Butterworths Scientific Publications 7

C. & M. Engineering Co., Ltd. 101
Cableform 52
Caird, F., Ltd. 83
Canty, H. G., & Partners 2
Carruthers, J. H., & Co., Ltd. 19
Carter, B. & F., & Co., Ltd. 122
Clarke, Chapman & Co., Ltd. 127
Clayton, Son & Co., Ltd. 103
Clyde Blowers, Ltd. 91
Clyde Crane & Booth, Ltd. 128
Clyde Crane & Engineering Co. 128
Cochran & Co., Annan, Ltd. 66
Cohen, G., Sons, & Co. Ltd. Cover iii–29–149
Conveyor & Elevator Co., (1936), Ltd. 18
Cox & Danks, Ltd. 135
Crofts (Engineers), Ltd. 132
Crompton Parkinson. Ltd. 95
Crossley - Premier Engines, Ltd. 27
Crowthorn Engineering Co., Ltd. 49
Czechoslovak Chamber of Commerce 48

Dick, R. & J., Ltd. 72
Doncaster, D., & Sons, Ltd. 119
Dore, J., & Co., Ltd. 37
Dorman Long (Bridge & Engineering), Ltd. 28
Doulton Industrial Porcelains, Ltd. 115

East Sussex Engineering Co., Ltd. 145
Edwards, F. J., Ltd. 148
Electrical Energy 45
Electronic Engineering 135–142
Electropower Gears, Ltd. 136
English Electric Co., Ltd. 120
Excelsior Motor Co., Ltd. 74

Fairman Precision Tools & Products, Ltd. 133
Faraday, M., & Partners, Ltd. 2
Farley Steel Industries, Ltd. 68
Farmer, L., & Sons 2
Fenner, J. H., & Co., Ltd. 69
Ferranti, Ltd. 104
Fielding & Platt, Ltd. 155
Financial Times 109
Flexello Castors & Wheels, Ltd. 21
Flexible Ducting, Ltd. 42

PAGE

Foord, J., & Co. 2
Foundry Services, Ltd. 148
Fowler, J., & Co. (Leeds), Ltd. 161
Foyles 138
Fuller, Horsey, Sons & Cassel 2

Gardner, J., & Co., Ltd. 42
General Electric Co., Ltd. 126
Gibson, J., & Son, Ltd. 78
Gimson & Co. (Leicester), Ltd. 55
Glenfield & Kennedy, Ltd. Cover ii
Goodwin, R., & Sons (Engineers), Ltd. 101
Govan Shafting & Engineering Co. 13
Grafton Cranes, Ltd. 52
Great Eastern Oil Co., Ltd. 72
Green, E., & Son, Ltd. 52
Greening, N., & Sons, Ltd. 101
Greenwood & Batley, Ltd. 71
Greenwood's Standard Gear Cutting Co., Ltd. 94
Griffiths, Gilbart, Lloyd & Co., Ltd. 83
Guest Keen Iron & Steel Co., Ltd. 76

Halesowen Steel Co., Ltd. 24
Harland & Wolff, Ltd. 111
Harvey, G. A., & Co. (London), Ltd. 102
Hayward Tyler & Co., Ltd. 160
Head, Wrightson & Co., Ltd. 68
Heap, J., & Co., Ltd. 115
Heenan & Froude, Ltd. 44
Hingley, N., & Sons, Ltd. 58
Holmes, W. C., & Co., Ltd. 60
Horne Engineering Co., Ltd. 126
Hot Dip Galvanizers' Association. 80
Howard, S., Ltd. 139

Imperial Chemical Industries, Ltd. 151–157
Ince Forge Co. 126
Ironmonger 44
Iso-Speedic Co., Ltd. Cover iv

Jackman, J. W., & Co., Ltd. 138
Jackson, E., & Co. (M/C), Ltd. 147

Keith Blackman, Ltd. 57
Kempe's Engineers Year-Book 159
Kitchen & Wade, Ltd. 42
Knight, Frank & Rutley 2

Laidlaw, Drew & Co., Ltd. 153
Lang Pneumatic, Ltd. 129
Larkinson, F. C., Ltd. 126
Lawrie, J. & T., Ltd. 95
Ledward & Beckett, Ltd. 89
Leeds Engineering & Hydraulic Co., Ltd. 38

PAGE

Lee, W., & Sons 100
Lloyd, F. H., & Co., Ltd. 51
Lloyds (Burton), Ltd. 105
Lobnitz & Co., Ltd. 18
Long Meadow Felt Co. 113

MacLellan, P. & W., Ltd. 94
McNeil, C., Ltd. 37
Main, A. & J., & Co., Ltd. 122
Mallinson & Eckersley, Ltd. 163
Marshall, J., & Co. (Motherwell), Ltd. 117
Marston Excelsior, Ltd. 59
Martin, Black & Co. (Wire Ropes), Ltd. 82
Mason, E. N., & Sons, Ltd. 76
Matthews & Yates, Ltd. 67
Maxim Conveyors (England), Ltd. 125
Menck & Hambrock G.m.b.H. 17
Metaducts, Ltd. 158
Metalastik, Ltd. 25
Metallic Manufacturing Co., Ltd. 90
Metropolitan-Cammell Carriage & Wagon Co., Ltd. 60
Metropolitan Plastics, Ltd. 79
Metropolitan - Vickers Electrical Co., Ltd. 1
Midland Galvanizers, Ltd. 162
Mills, G. (Engineers), Ltd. 36
Mirrlees (Engineers), Ltd. 78
Mirrlees Watson Co., Ltd. 39
Modern Conveyors, Ltd. 89
Modern Machine Tools, Ltd. 94
Mond Nickel Co., Ltd. 162
Monk, A., & Co., Ltd. 87
Monochrome, Ltd. 107
Mono Pumps, Ltd. 37
Morgan Bros. (Publishers), Ltd. 133
Murad Developments, Ltd. 44

National Gas and Oil Engine Co., Ltd. 20
Neill, J., & Co. (Sheffield), Ltd. 142
Newalls Insulation Co., Ltd. 41
Niagara Screens (Great Britain), Ltd. 70
Nitralloy, Ltd. 94
Non-Ferrous Die Casting Co., Ltd. 104
Norgren, C. A., Ltd. 143
Northare Organisation 101

Opperman, S. E., Ltd. 118
Osborn, S., & Co., Ltd. 124
Oscard, J., & Co. 54

Parker, F., Ltd. 100
Parsons, C. A., & Co., Ltd. 84
Passe, J. F., & Co. 138
Pegler, Ltd. 147
Permali, Ltd. 91

PAGE

Plastics Johnson & Co. 55
Pioneer Oilsealing & Moulding Co., Ltd. 140
Pitman, Sir Isaac, & Sons, Ltd. 7
Platt Malleable Castings, Ltd. 159
Plenty & Son, Ltd. 117
Plowright Bros., Ltd. 130
Pohlig, J., Aktiengesellschaft 62
Pollard, F., & Co., Ltd. 54
Positive Lock Washer Co., Ltd. 135
Potter, F. W., & Soar, Ltd. 126
Pratt, R. 107
Price, J. T., & Co., Ltd. 111
Prior Stokers, Ltd. 57

Q.V.F., Ltd. 62

R.D.C. 163
Radiovisor Parent, Ltd. 144
Rapid Magnetic Machines, Ltd. 89
Rawplug Co., Ltd. 57
Rayner, P., Ltd. 36
Reavell & Co., Ltd. 54
Regent Oil Co., Ltd. 99
Renold Chains, Ltd. 129
Reyrolle, A., & Co., Ltd. 73
Rhodes, B., & Son, Ltd. 92
Rhodes, J., & Sons, Ltd. 58
Richards & Partners 2
Riley, A. J., & Son, Ltd. 39
Robertson & Ferguson, Ltd. 13
Robey & Co., Ltd. 56
Robson, G., & Co. (Conveyors), Ltd. 13
Rolls-Royce, Ltd. 130
Rubert & Co., Ltd. 115
Ruhrstahl A.G. 81
Russell, G., & Co., Ltd. 163

St. Georges Engineers, Ltd. 138
Sanderson Bros. & Newbould, Ltd. 140
Saunders Valve Co., Ltd. 43
Savery, T., Pumps, Ltd. 145
Schieldrop & Co., Ltd. 140
Schiess A.G. 46
Senior Economisers, Ltd. 75
Sharp Control Gear, Ltd. 21
Shawe Metal Spinning Works 49
Shotton Bros., Ltd. 89
Silentbloc, Ltd. 96
Sinex Engineering Co., Ltd. 126
Skefko Ball Bearing Co., Ltd. 88
Skinningrove Iron Co., Ltd. 41
Small, W. H., Ltd. 49
Smedley Bros., Ltd. 91
Smith Bros. & Co. (Hyson), Ltd. 92
Smith & McLean, Ltd. 104
Soag Machine Tools, Ltd. 159
Spencer - Bonecourt - Clarkson, Ltd. 49
Standard Piston Ring & Engineering Co., Ltd. 55

PAGE

Stein, J. G., & Co., Ltd. 71
Sterling Foundry Specialties, Ltd. 121
Stubs, P., Ltd. 44
Suffolk Iron Foundry (1920), Ltd. 107
Sulzer Bros. (London), Ltd. 164
Superheater Co., Ltd. 126
Super Oil Seals & Gaskets, Ltd. 63

T.I. Aluminium, Ltd. 14
Tangyes, Ltd. 65
Taylor & Challen, Ltd. 66
Taylor & Hubbard, Ltd. 91
Taylor Woodrow 40
Technological Institute of Gt. Britain. 5
Teddington Industrial Equipment, Ltd. 34
Teleflex Products, Ltd. 90
Terry, H., & Sons, Ltd. 34
Thorn, J., & Sons, Ltd. 103
Thornton, B., Ltd. 154
Tonks, J., & Co., Ltd. 91
Triplex Foundry, Ltd. 147
Tufnol, Ltd. 85
Turner Bros. Asbestos Co., Ltd. 152
Twiflex Couplings, Ltd. 15

Unbrako Socket Screw Co., Ltd. 122
United Dominions Trust, Ltd. 38
United Steel Structural Co., Ltd. 114

Varatio-Strateline Gears, Ltd. 50
Varityper Distributors (Gt. Britain), Ltd. 16
Vickers-Armstrongs (Engineers), Ltd. 26
Vokes, Ltd. 106

Walker Bros., Ltd. 144
Walker, C. & W., Ltd. 56
Ward, T. W., Ltd. 13–36–86
Wareing Bros. & Co., Ltd. 70
Warne, Wright & Rowland, Ltd. 131
Weir, G. & J., Ltd. 35
Weldall & Assembly, Ltd. 141
Wellman Bibby Co., Ltd. 101
Wellman Smith Owen Engineering Corporation, Ltd. 137
West Ham Testing Laboratory. 13
Weston, C., & Co., Ltd. 97
Westwood, J., & Co., Ltd. 136
Wheatley Kirk Price & Co. 2
White, R., & Sons, Engineers, Ltd. 133
Wickman, Ltd. 61
Wiggins, F., & Sons 163
Wiseman, A., & Co. Ltd. 154
Woodhouse & Mitchell 133
Worthington-Simpson, Ltd. 23

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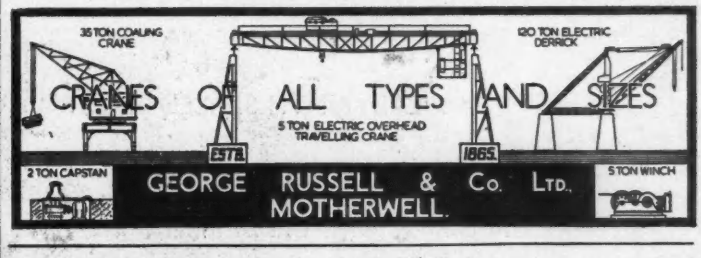

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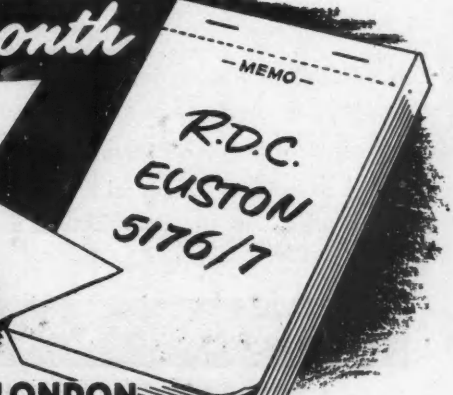

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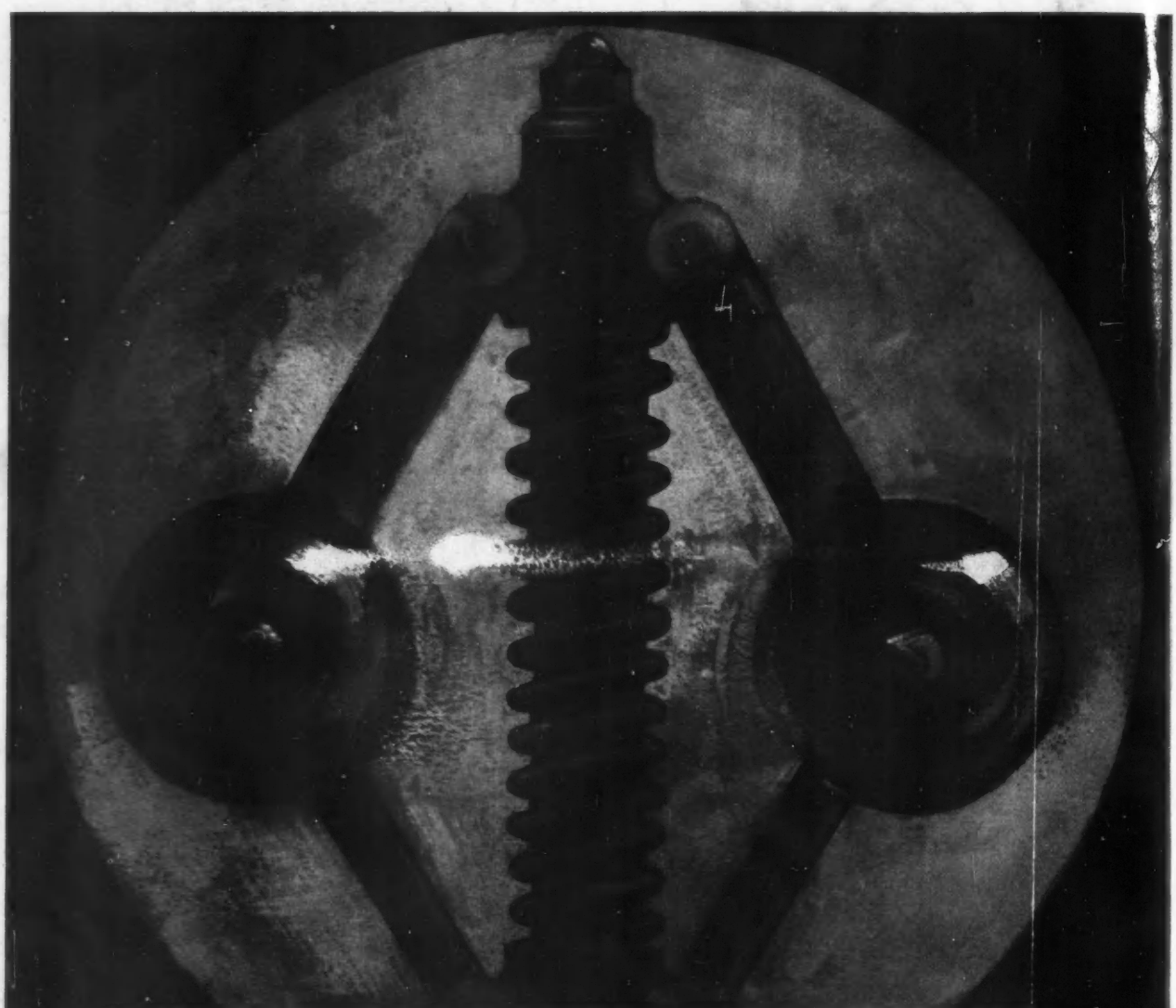

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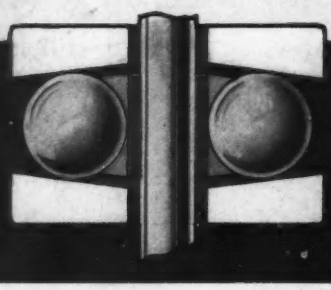
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